Vol. 15 No. 12 December 1961 Published Monthly

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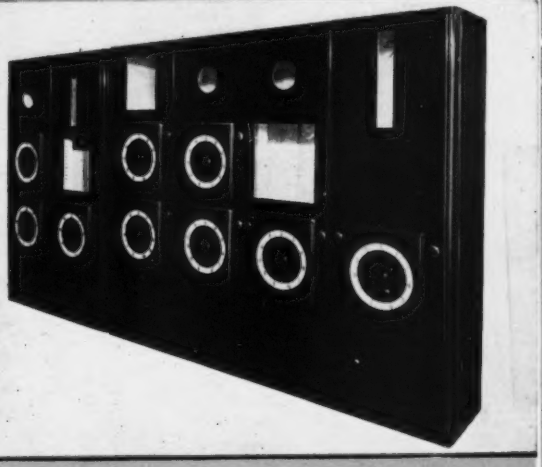

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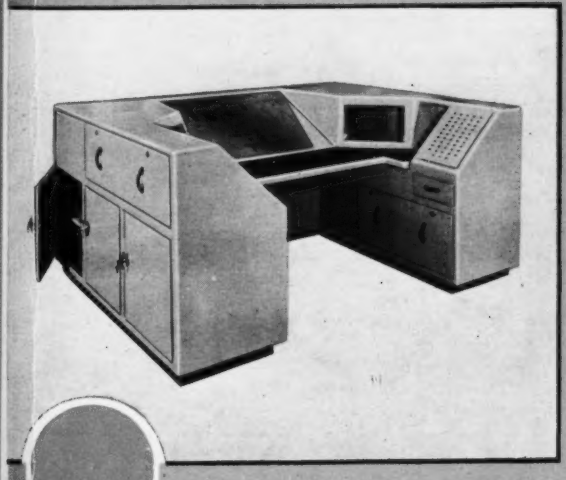

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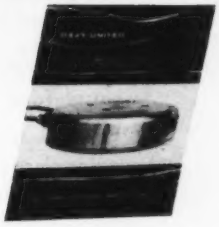

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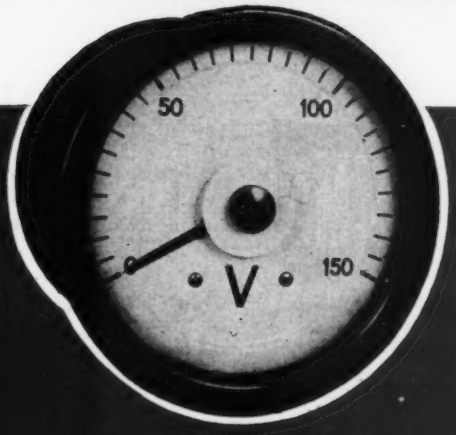

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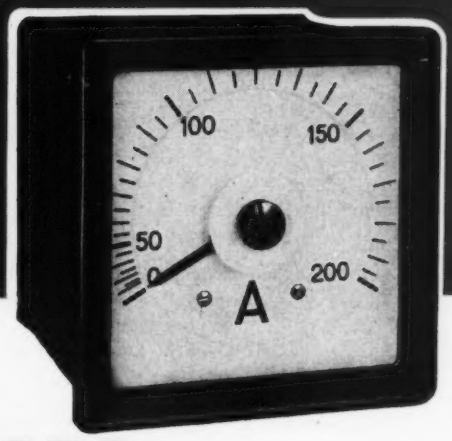

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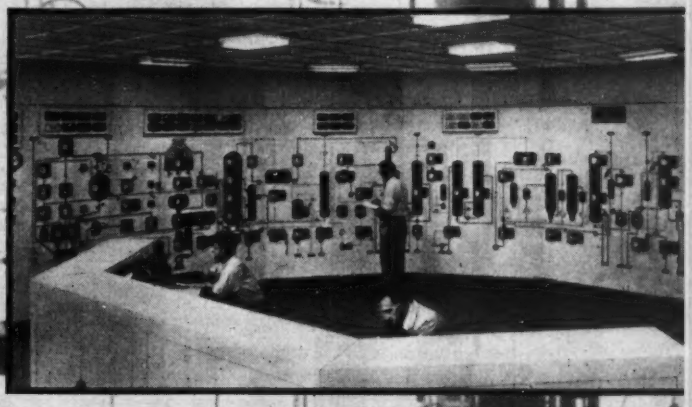

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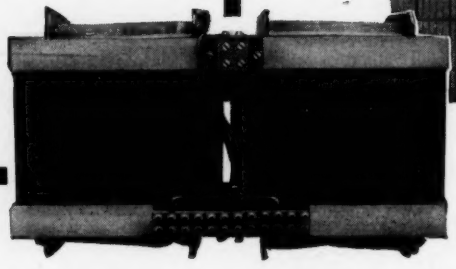
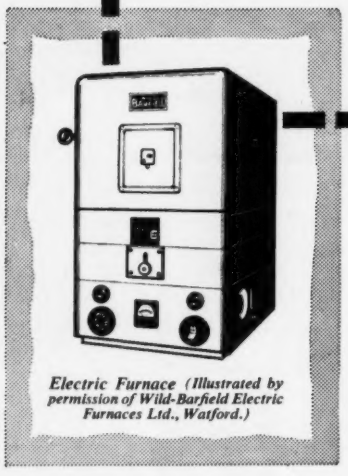


Saturable Reactor



Electric Furnace (Illustrated by permission of Wild-Barfield Electric Furnaces Ltd., Watford.)

This controller incorporates a photoelectric system which provides a direct-current output proportional to the deviation of the pointer from the desired-temperature value. The current is amplified by a magnetic amplifier as necessary to give the full range of control of a saturable reactor, which is connected in series with the furnace. The system gives stepless control of the furnace voltage from 10%—90% of the supply value over the proportioning band, which is adjustable between 5%—10% of the temperature range.

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Qualified engineers in our Research and Development laboratories at Glenrothes are available to help with your application problems.

Actual size

Type No.	Continuous ratings 25°C		Characteristics 25°C	
	Max. Reverse Volts	Max. Forward Current	Max. Volts Drop	Max. Reverse Current
HG5001	100	80 mA	.8 v @ 100mA	5μA @—50V
HG5002	70	80 mA	.8 v @ 100mA	5μA @—50V
HG5003	100	80 mA	.8 v @ 100mA	25μA @—50V
HG5004	70	80 mA	.8 v @ 100mA	25μA @—50V
HG5005	100	80 mA	.8 v @ 100mA	50μA @—50V
HG5006	70	80 mA	.8 v @ 100mA	50μA @—50V
HG5007	40	80 mA	.8 v @ 100mA	5μA @—30V
HG5008	40	80 mA	.8 v @ 100mA	25μA @—30V
HG5009	40	80 mA	.8 v @ 100mA	50μA @—30V

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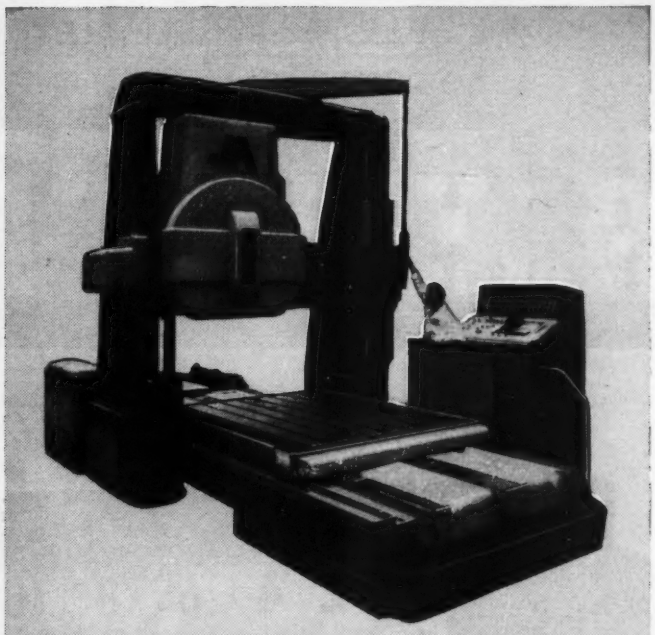

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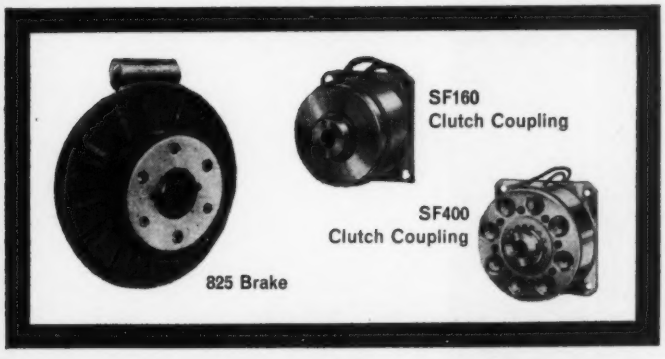

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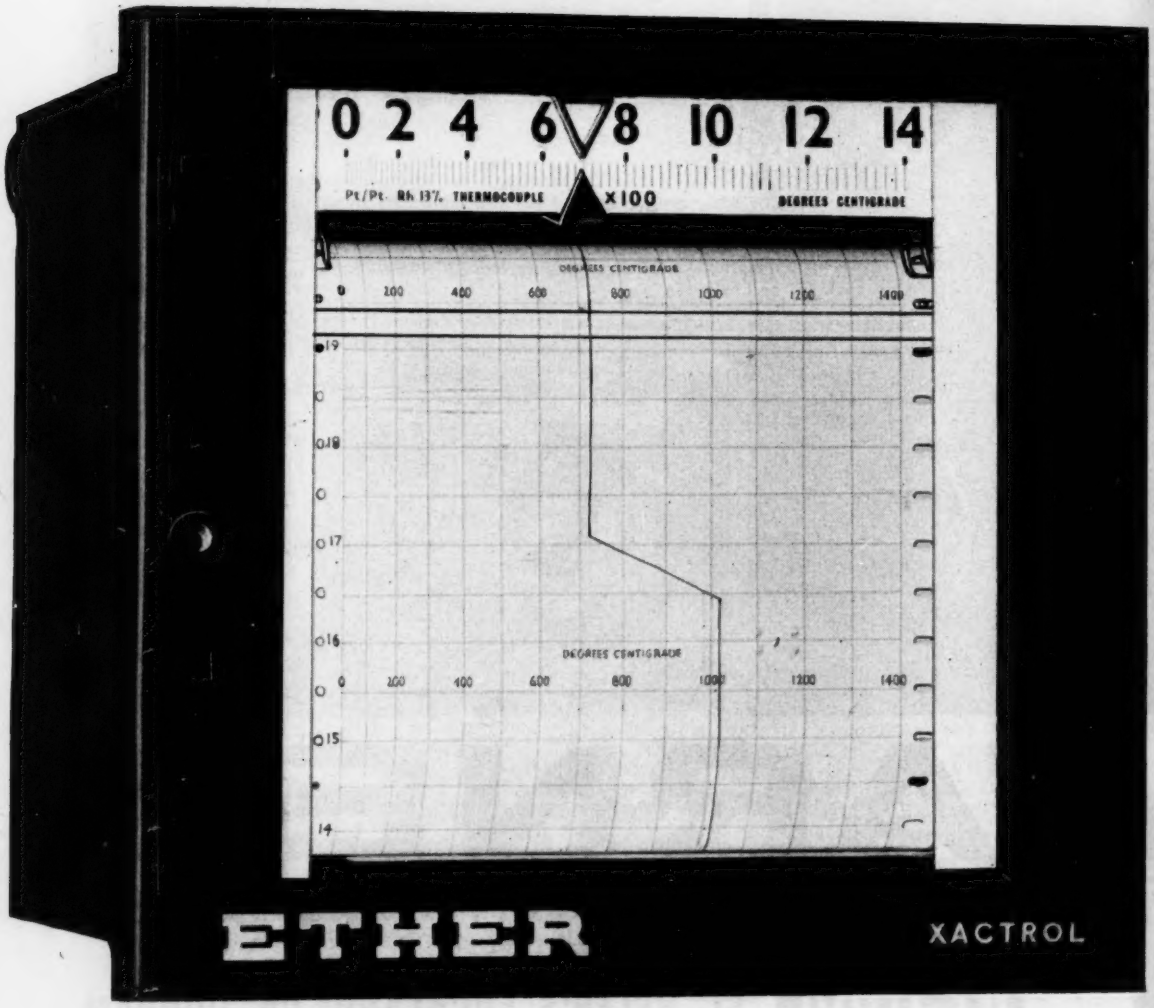

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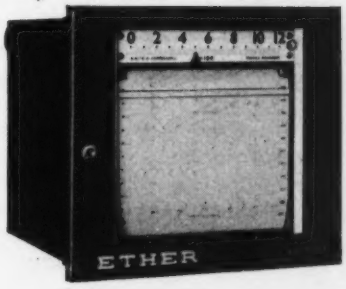
Single-point Potentiometer Recording Controllers

6" calibrated scale * Standard ranges: 2mV-100mV span
Pen speed: 1, 2 or 4 secs. across chart * Chart life: 1 month at 1 inch per hour.

Available with (i) Two-position on/off control (ii) Anticipatory control (iii) Proportioning (electrical) control (iv) Three-position control (v) Programme control (vi) Proportioning (motorised) control



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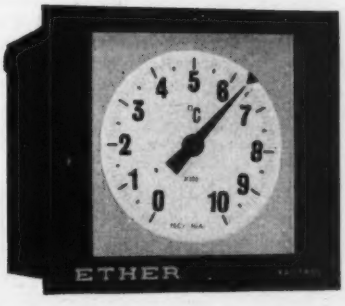

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A WORLD OF VIBRATION

Vibration technology is a comparatively new development in the field of environmental engineering. Its applications in measuring metallurgical stresses and strains, in simulating fatigue to destruction point, are fairly well-known, but even the present scope is far wider than these. The potential is immense to a degree which possibly outreaches that of any other applied science. It is even possible that there is much to be rediscovered, for the histories and mythologies of ancient civilizations abound in references to physical motion achieved through sound vibrations. The destruction of the walls of Jericho is an example; and it has been suggested that the Pyramids' vast masonry was elevated by similar means. But fascinating and perhaps revealing as that line of inquiry may be, this report will deal principally with the immediately practical uses of vibration testing.

From eyes to motor cars is an apt and related part of the applications range. Taking the first and uncomfortably picturesque example, an incidence of severe headaches and impaired vision suffered by transport drivers led to tests with vibration equipment. These showed that through vibration on certain road surfaces, the drivers' eyes were being literally bounced back and forth in their sockets.

MOTOR VEHICLE INDUSTRY

Car bodies and their attachments are subject to mechanical and other vibrations transmitted through suspension systems. What with wear and tear and varying concern for maintenance, the noises which can result are an age-old problem at the service station. The drumming heard by the owner 'under the back seat somewhere' is usually non-existent in normal workshop testing; out on the road it's audible but locating it is a tedious and uneconomic guessing game.

Yet further complications arise out of the fact that the vibration source may be far removed from the apparently offending component or structure.

We have a compact generator/oscillator/power amplifier combination by which all the running vibrations can be simulated *in the workshop* and the noise source accurately and quickly located. Similar equipment is used by car manufacturers so that vibrations can be compensated or designed out.

ROAD CONSTRUCTION

Roads, too, can be investigated with vibration equipment. An applied vibration is picked up at a distance, on an oscilloscope. The signal time and strength factors vary according to the nature and thickness of the surface and subgrade materials. By these readings it can be determined whether or not the construction is according to specification. Periodic tests will reveal the extent of any deterioration. In research, the behaviour of roads under various traffic conditions can be established and the information used in framing specifications for new roadworks.

AIRCRAFT INDUSTRY

In the aircraft industry, vibration testing has long been a vitally important technique. Bearing in mind the possible outcome of the failure of quite small components, vibration problems in land vehicles and structures pale into comparative insignificance. Goodmans equipment is widely used to test dynamic models . . . even whole aircraft . . . and on the multiplicity of instruments and electronic apparatus.

The tremendous power and complexity of rocket-propelled vehicles set still more-exacting requirements and for these Goodmans are producing special generators.

OTHER APPLICATIONS

The miscellany of these is far too extensive to catalogue here, but the following will serve to demonstrate the scope.

In fatigue testing, vibration generators provide wide range and prolonged consistency.

Chemical and bio-chemical research are served by our smallest generator, the V47, in mixing, emulsifying and the measurement of interface potentials. It has been used also to simulate nerve signals and to assess vibration effect on living tissue. Experiments show that physical vibration and 'white noise' have anaesthetic properties.

Vibration equipment is used in the rubber, plastic and textile industries, as an aid in establishing the materials' mechanical properties.

Experiments in the machine tool industry have shown that small and carefully controlled vibrations can, in fact, improve stock removal, surface finish and minimize the effect of certain operations upon molecular structure.

This is inherently a world of movement. Everything vibrates within itself and often as an entity. These forces can be observed, reproduced, supplemented. There must therefore be many functions for our vibration equipment which even we can only guess at . . . and even more as yet unthought of. Name your problem; consider what may be done better, faster, more economically . . . what may be done perhaps for the first time, with the help of vibration equipment. It's more than likely that the means to the end is ready-made.

Goodmans electro-mechanical vibration generators, the largest range in Europe, comprise:

TYPE	PEAK THRUST
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790	35 lb
8/600 Mk.II	300 lb
VG109 Mk.III	18.000 lb

There is available a corresponding range of oscillators and power amplifiers

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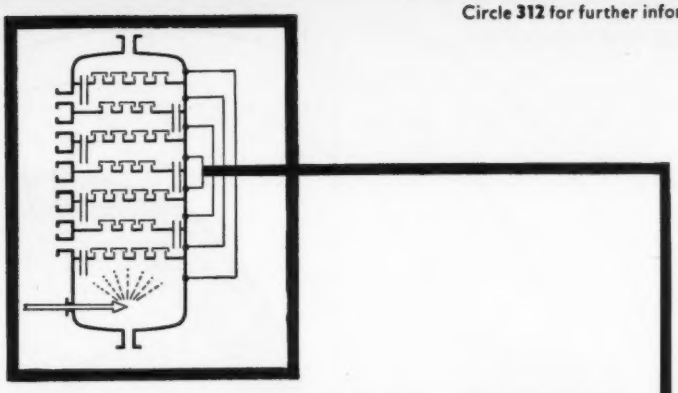
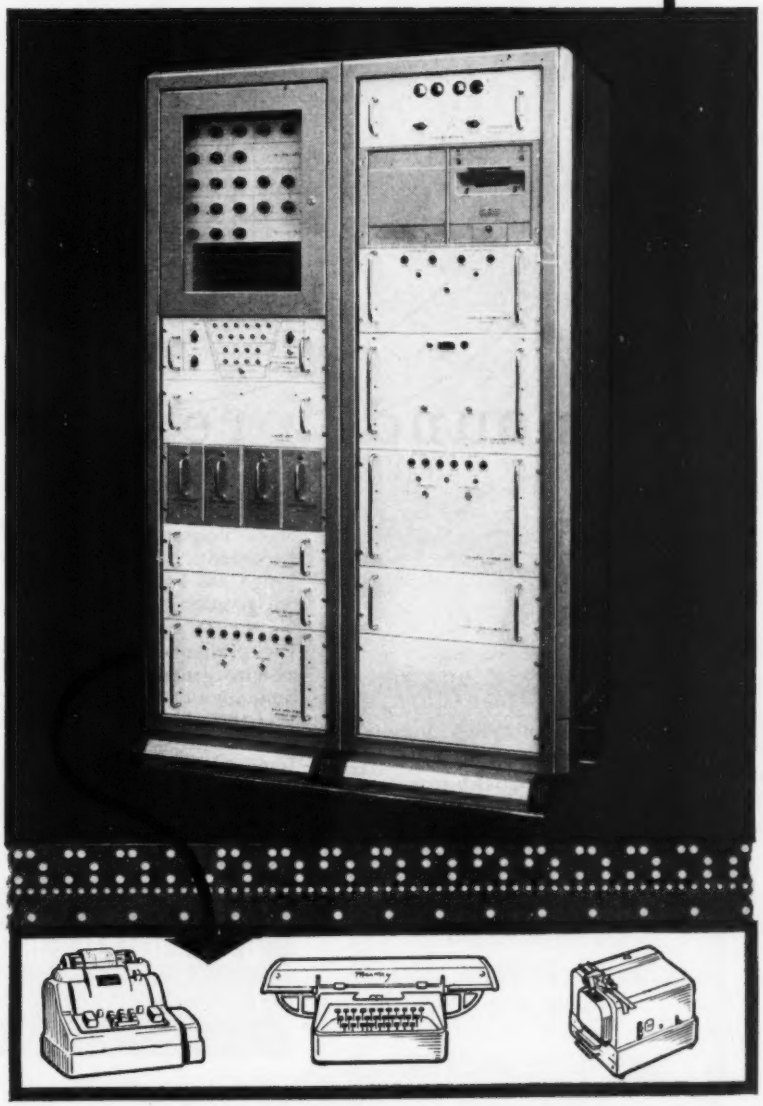


BE Data Logging Equipment

An accuracy of ±0.2% and a high scanning speed make Blackburn Electronics data logging equipment ideal for monitoring plant performance. Modular construction of the basic units enables instrument engineers to install exactly the right size of this inexpensive and compact equipment necessary for data monitoring and recording on their plant. Extension of the logger by multiples of 10 channels is possible as required.

Input signals derived from thermocouples and other transducers can be scanned at a rate up to 20 points a second. Departure of any parameter from predetermined limits is indicated by visual and audible alarms and a parameter record. Alarm conditions may also open relay contacts for process control applications. The output data may be obtained on a strip or page printer or paper tape punch and will comprise parameter identification, value and time, etc.

A complete log of all parameters may be obtained on demand and at regular intervals.



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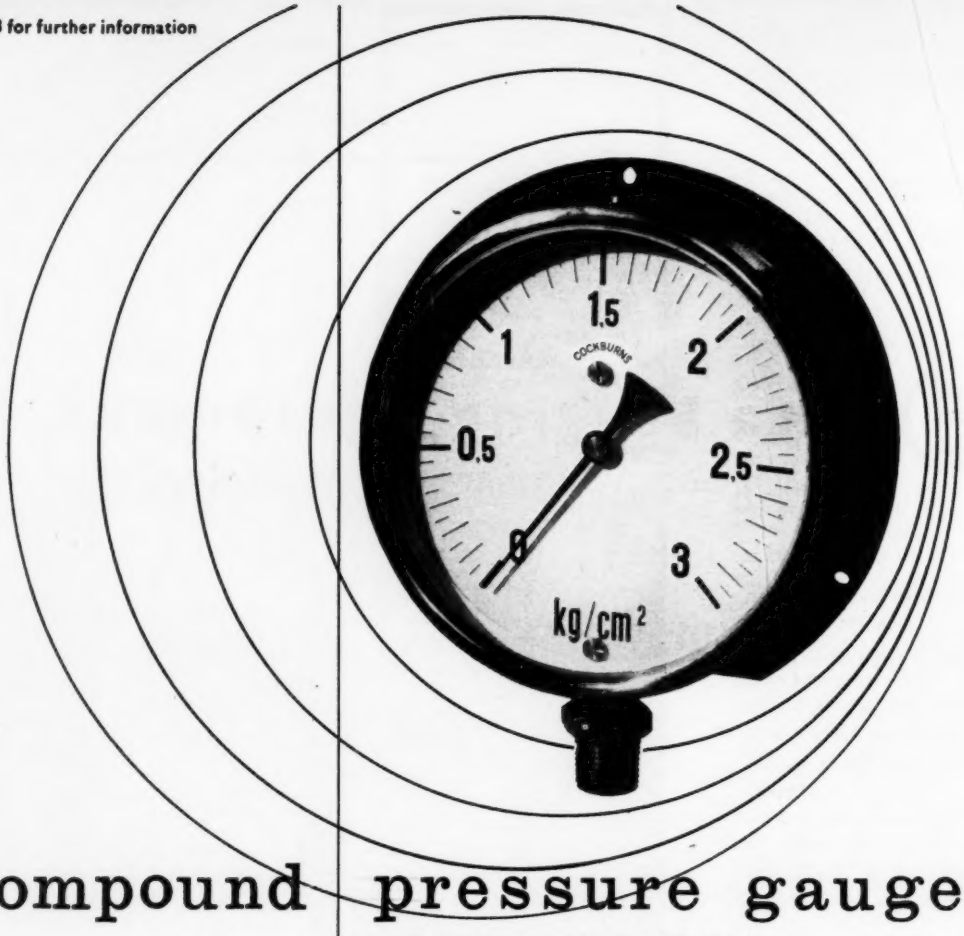

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with zero adjustment

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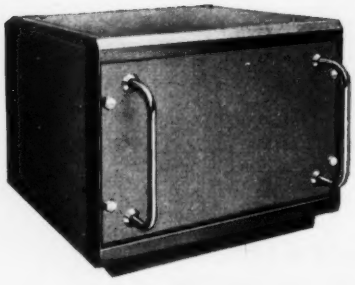

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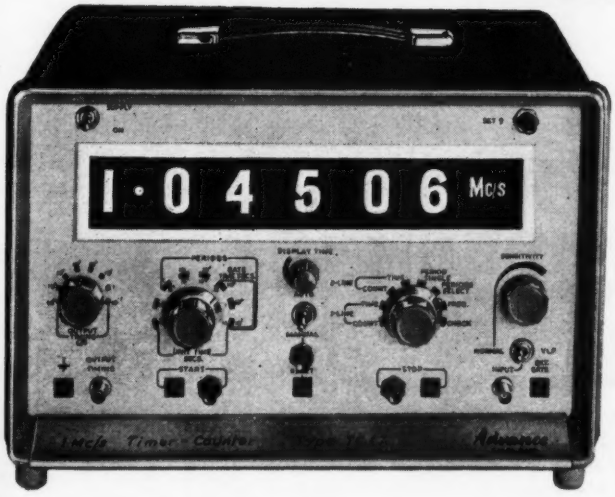
QUICK ACCURATE READINGS

are possible with the latest timer-counter by Advance which incorporates an easy-to-read in-line display with automatic decimal point and units of measurement indicator. The internal frequency standard is a temperature compensated crystal oscillator which enables accurate measurements to be taken as soon as the instrument is switched on.

TC1A

1·04506 Mc/s



1 Mc/s Timer-Counter
TYPE TCIA FEATURES

IMPROVED SIX FIGURE DISPLAY with in-line presentation.

INTERNAL STANDARD is a temperature compensated crystal oscillator accurate to ± 1 part in 10^6 between + 10°C and + 30°C.

FREQUENCY MEASUREMENTS from d.c. up to at least 1 Mc/s.

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TIMING PULSE OUTPUT from 10^{-1} up to 10^6 pulses per second.

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SB1/5

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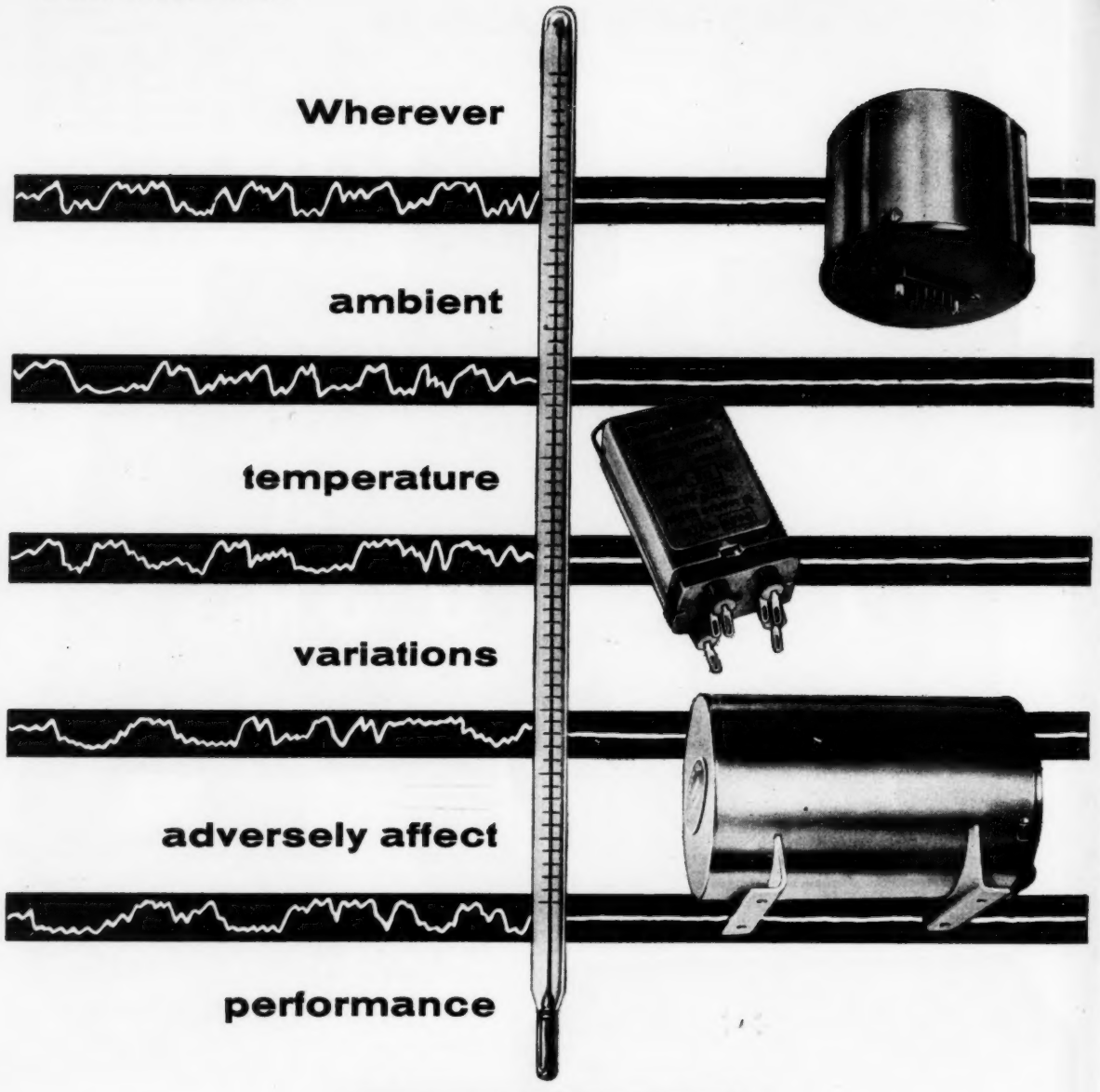

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Temperature differentials better than ± 0.05°C to ±2°C over extreme ambient temperature ranges can be readily achieved. Where temperature differentials better than ±0.5°C are required the sensing element is usually in the form of mercury contact thermometer operating a relay or transistor circuit (external to the oven) which controls the heating power. Complete control mechanisms contained within the oven are often in the form of a simple bi-metal thermostat ... Applications:- Quartz crystals, transistors, thermistors and similar devices sensitive to ambient temperature variations.

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Philips H.F. Service Oscilloscope GM 5600 has been expressly designed for the needs of the Instrument Service Engineer in Industry, Telecommunications, Radio and Television. It is a compact, readily portable equipment.

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— DC coupled amplifier up to 5Mc/s,
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C.R.T.
— 7 cm flat faced C.R.T. with 1.6 kV accelerating voltage.

H.F. Service Oscilloscope Type GM 5600

The range of Philips Oscilloscopes

	Vertical amplifier			Time base			
Type	*Band Width to −3dB*	*Sensitivity per cm.*	*Input Impedance*	*Sweep Speeds*	*Magnification*	*Trigg./Sync*	*Tube Size E.M.T.*
GM 5600	DC – 5 Mc/s	50 mVp-p ± 4% (a)	1MΩ//45μμF with probe 10MΩ//8μμF	0.5 μsec/cm – 180 msec/cm	—	Trigg.	7cm 1·6kV
GM 5601	DC – 5 Mc/s	100 mVp-p ±3% (a) (b)	0.5MΩ//35μμF with probe 10MΩ//8μμF	0.1 μsec/cm – 0.2 sec/cm ± 3% (a)	5x (a)	Trigg.	10cm 3kV
GM 5602	3 c/s – 14 Mc/s	75 mVp-p ± 2% (a) (b)	0.5MΩ//12μμF with probe 10MΩ//5μμF	40mμsec/cm 10 msec/cm ± 3% (a)	2x, 5x (a)	Trigg./Sync	10cm 4kV
GM 5603	DC – 14 Mc/s	50 mVp-p ± 3% (a) (b) (c)	1MΩ//22μμF with probe 10MΩ//10μμF	40mμsec/cm 1 sec/cm ± 3% (a)	2x, 5x (a)	Trigg./Sync	13cm 10kV
GM 5606	DC – 200 Kc/s	10 mVp-p ± 3% (a) (b)	1MΩ//20-50μμF	50mμsec/cm 1 sec/cm (a)	5x (a)	Trigg.	10cm 3kV
GM 5639 'x-y' Oscilloscope	'y' DC – 1 Mc/s 'x' DC – 1 Mc/s	100 mVp-p ± 3% 200 mVp-p ± 3%	1MΩ//15-40μμF 1MΩ//15-40μμF	2 μsec/cm – 500 msec/cm ± 5%	—	Trigg.	10cm 3kV

(a) Direct calibrated *(b) Calibration standard(s) incorporated* *(c) Differential input*

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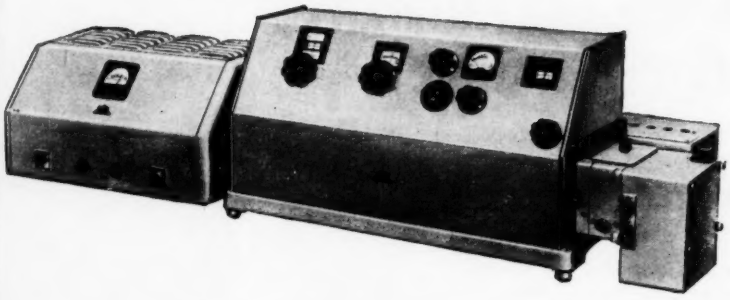
UNICAM

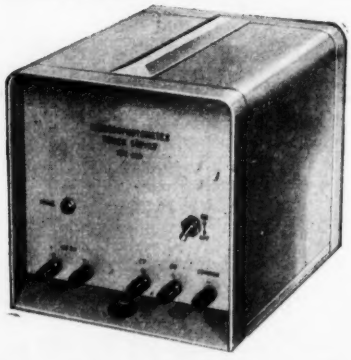
SP. 500



SPECTROPHOTOMETER

For Ultraviolet, Visible and Near Infrared analysis of compounds the SP.500 Spectrophotometer is accepted as standard equipment in every laboratory. One essential which contributes to the highly accurate data provided by the SP.500 is a stable mains supply or the use of a lead acid storage battery. For those users who prefer a mains supply, Labgear Ltd. have developed the 'Spectrophotometer Power Supply' pictured below and after thorough testing we are satisfied that in all but the most adverse conditions this accessory will provide the necessary degree of stabilisation.

mains operation with the 115D



STABILISED POWER SUPPLY

The unit employs a conventional series stabilizer system, a compensating double zener reference being used to provide a high degree of stabilisation. Particular care has been taken in the design to minimise the temperature rise of the sampling and control components due to the heat dissipation in the series regulators. The use of the latest type power transistors together with cast alloy heat sinks permit the unit to operate in high ambient temperatures under adverse mains input conditions. First quality components are employed throughout making the unit suitable for pan-climatic use.

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(U.202)

This recording is typical of line voltage conditions in an industrial establishment where voltage variation is a problem.

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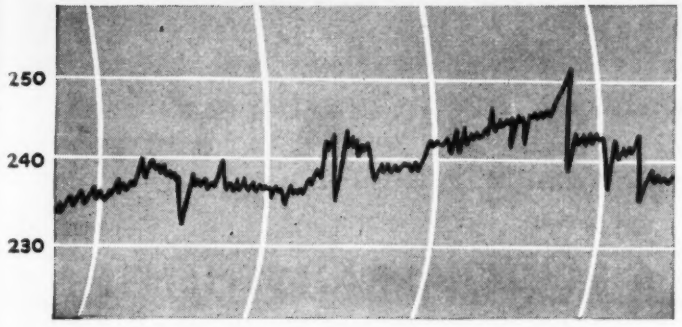
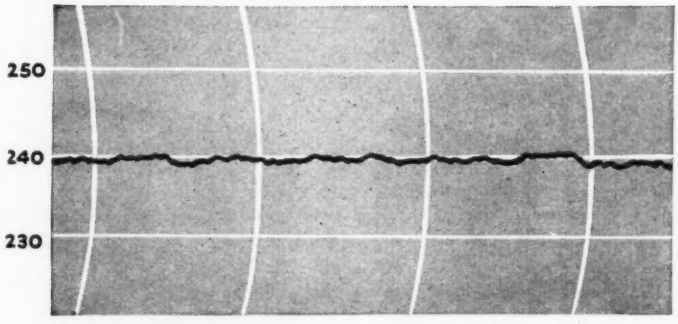
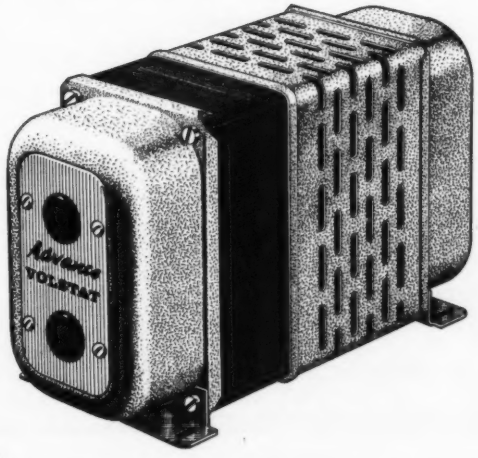


FLUCTUATING VOLTAGE



becomes constant with a

VOLSTAT



A VOLSTAT is the answer to many voltage fluctuation problems. In most cases, a standard type is all that is required—but there are occasions when a special design may be necessary. Either way, an 'Advance' Technical Representative will be pleased to investigate your own particular problems, and recommend a VOLSTAT best suited to your needs. VOLSTAT stands for a complete range of Constant Voltage Transformers produced by 'Advance'—the leading authority on voltage stabilization. Full details in Folder D63 available on request.

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MAINS STABILIZATION DIVISION
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SBVC/2

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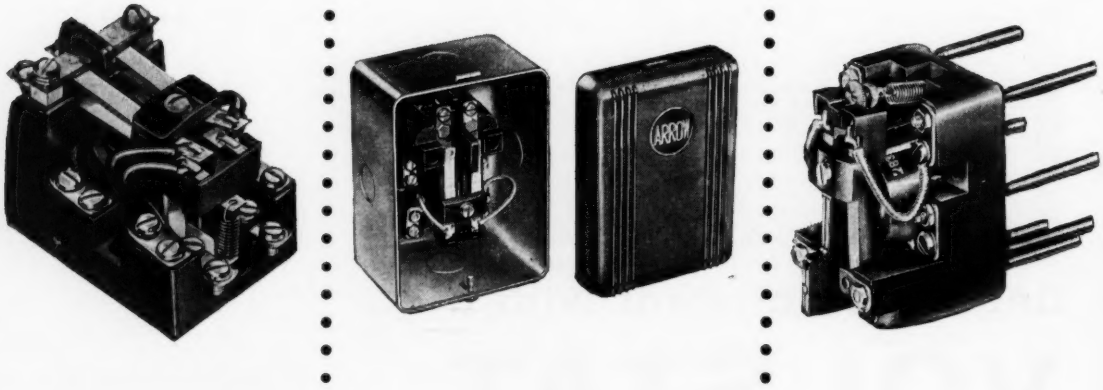

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AEI MIXED-GAS THYRATRONS

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★ FASTER STARTING ★ LONG, RELIABLE SERVICE LIFE
★ WIDE AMBIENT TEMPERATURE RANGE

YPE BT. 109

a 6.4-amp inert gas/mercury vapour thyratron. Fast arting. This valve is intended for industrial applications, d is a plug-in replacement for American type GL.6858.

TYPE BT. 113

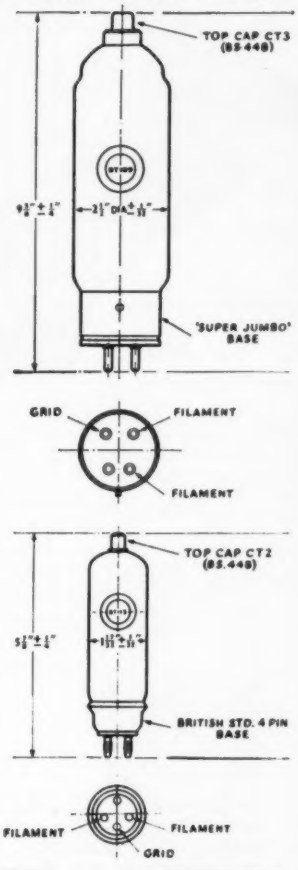
—a 0.5-amp inert gas/mercury vapour thyratron. May be used as a plug-in replacement for BT.19, where maximum peak anode voltage is not above 1,500 volts. Fast starting.

HARACTERISTICS

lectrical	BT. 109	BT. 113
athode type	Directly heated.	Directly heated.
lament voltage	2.5 volts	2.5 volts
lament current (max.)	23 amps	5.3 amps
lament current (min.)	19 amps.	4.5 amps.
oltage drop (max.)	15 volts.	15 volts.
athode heating time	60 secs.	30 secs.
nisation time (approx.)	4 micro secs.	10 micro secs.
ionisation time (approx.)	1000 micro secs.	1000 micro secs.
node-control capacitance	4 $\mu\mu$ farads.	2 $\mu\mu$ farads.
ntrol grid—cathode capacitance	18 $\mu\mu$ farads.	7 $\mu\mu$ farads.
echanical		
pe of cooling	Convection.	Convection.
ounting position	Vertical, base down.	Vertical, base down.
eight (max.)	(11¼ oz). (328 gm).	(2¾ oz.) (80 gm).
uilibrium condensed mercury mperature rise above bient (full load)	32°C.	(approx.) 24°C.
(no load)	29°C.	(approx.) 23°C.
atings		
ax. peak anode voltage: forward	1500 volts.	1500 volts.
inverse	1500 volts.	1500 volts.
ax. cathode current: peak	77 amps.	2 amps.
average	6.4 amps.	0.5 amps.
ax. averaging time	15 secs.	15 secs.
mbient temperature range*	—40°C. to +40°C.	—40°C. to +40°C.

Still air temperature near the base of valves.

though valves will operate satisfactorily at ambient temperatures of —40°C. to +10°C., e will be reduced at these low temperatures. For maximum life the valve should be operated ambient temperatures within the range +15°C. to +40°C.



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Others will want to see it. If you would like to have full details of these two new thyratrons, or any other AEI electronic components for that matter, all you have to do is write to AEI at the address below. Data sheets with detailed information will be sent to you without charge.

DON'T DELAY-*Write now and be sure of receiving latest news of these and other AEI components as they become available.*

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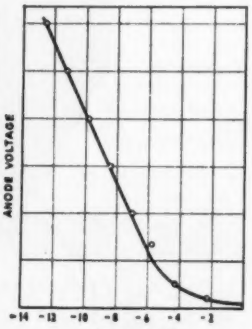
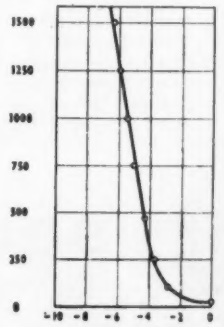


BT 113 Thyratron control characteristic



BT 109 Thyratron control characteristic

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BT. 109 & BT. 113 MIXED-GAS THYRATRONS

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a calculation of mathematicians

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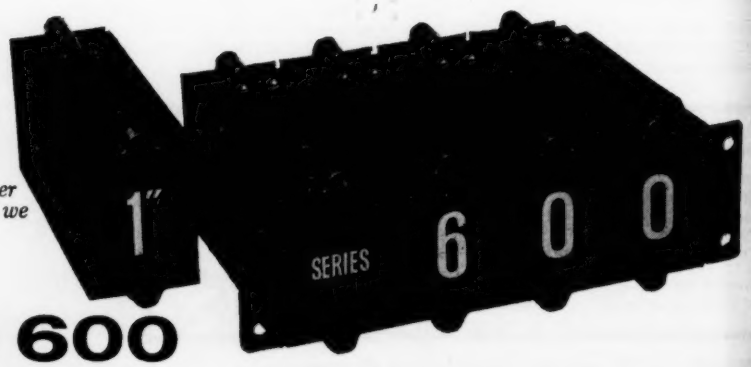

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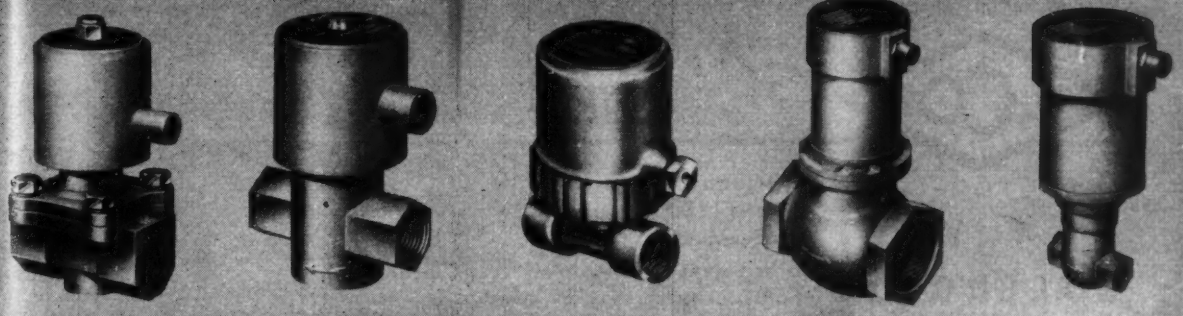

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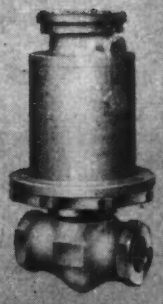

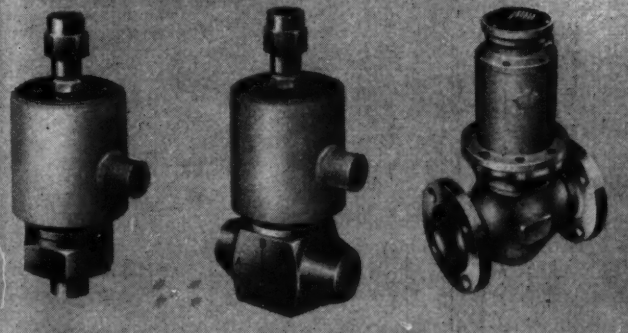

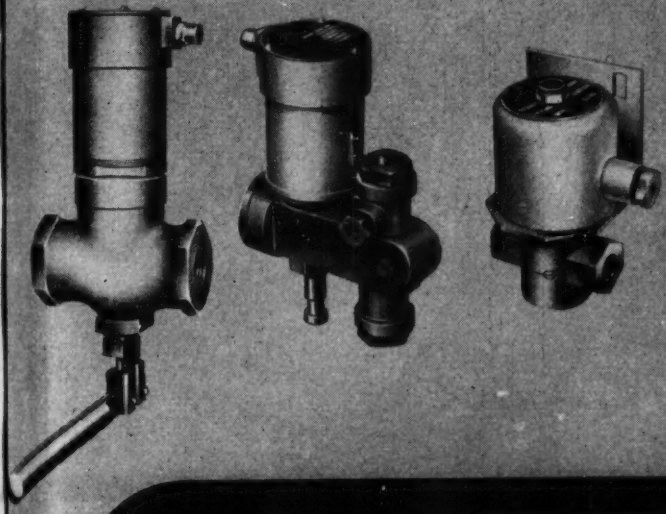

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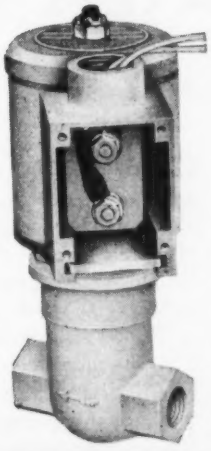

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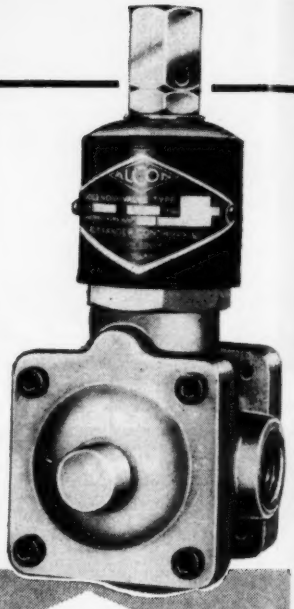

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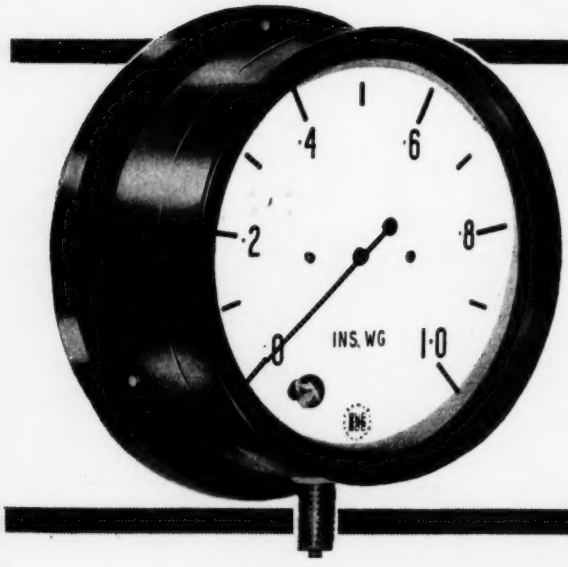

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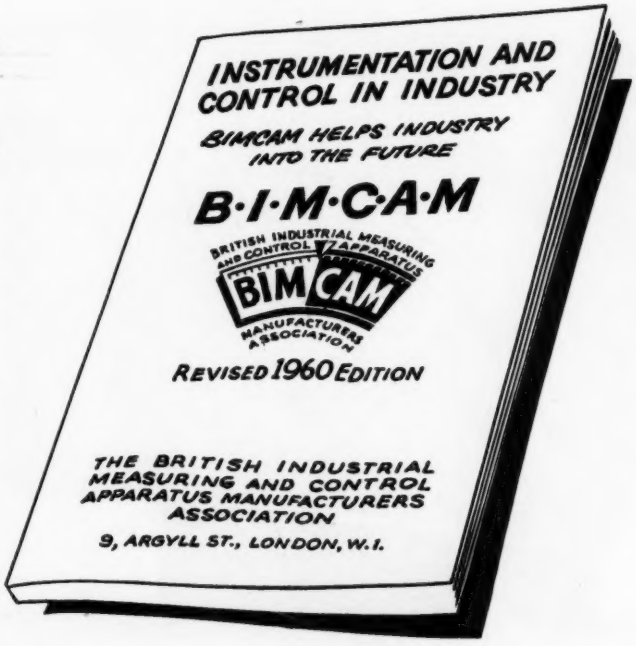
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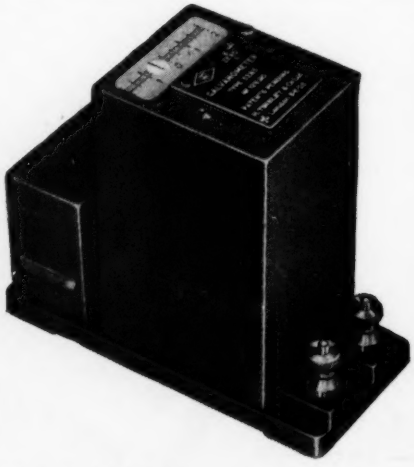
incorporates small-unit construction with standard "one metre light path" sensitivity



Type 5285, shown here, measures 2" x 4½" x 5" high, and weighs only 2½ lbs. It is sturdily constructed to the highest Tinsley standards of operating efficiency, and is specially designed for use with any of the suspensions shown below.

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10a	3	30	10	20
10b	5	95	19	90
10c	10	140	14	250
10d	50	300	6	1 200
10e	140	550	4	3 500
10f	450	1 500	3	12 000
1 sec. P.T.				
11a	3	9	3.0	8
11b	5	24	5.0	44
11c	10	30	3.0	130
11d	50	65	1.3	650
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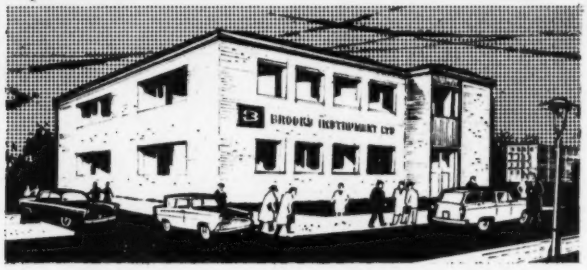

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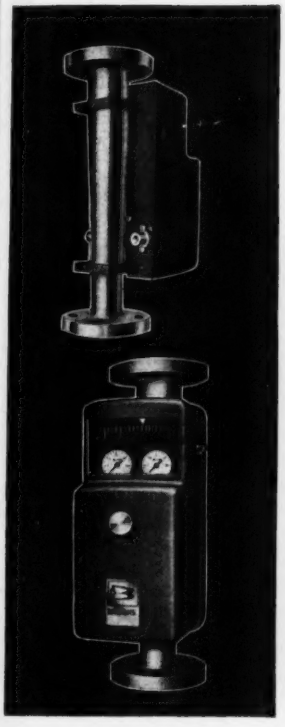
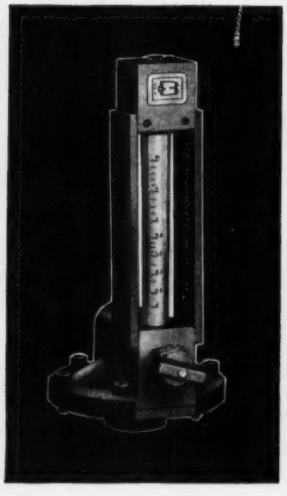
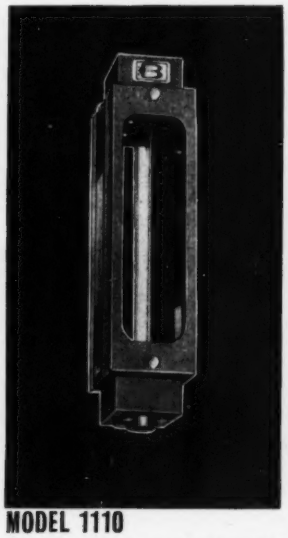
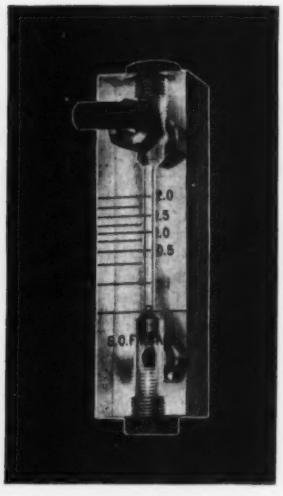
BROOKS flowmeters are now available in Britain



Brooks Instrument Co. Inc., Hatfield, Pennsylvania, U.S.A. announce the greatest advancement in flowmeter availability. The trusted and proven Brooks flowmeter is now available in Britain and throughout the continent of Europe. Following the formation of the Central European Controlling Office in Switzerland and other distributive points in Holland and Germany a new Company has been established to satisfy the requirements of industry in Britain — Brooks Instrument Limited, Brooksmeter House, Cross Lane, Marple, Cheshire. A company whose management and staff have many years experience in the service of instrument technology. Illustrated on these pages are just a few of the vast range of precision built and top-quality made Brooks flowmeters now available.







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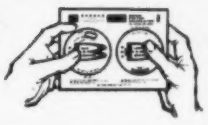

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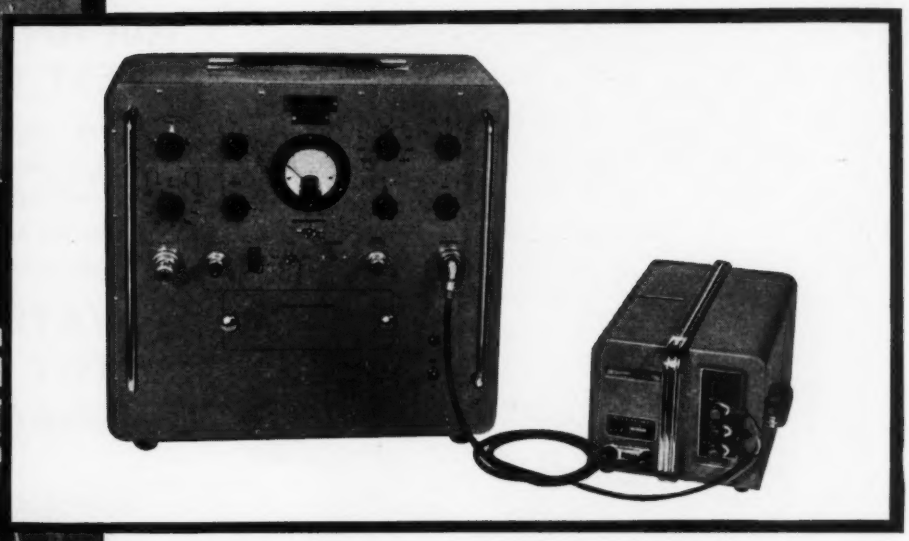

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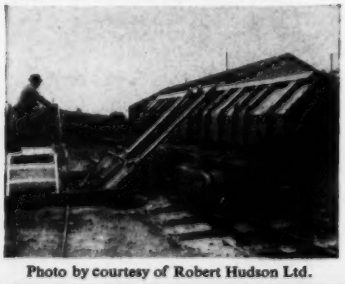

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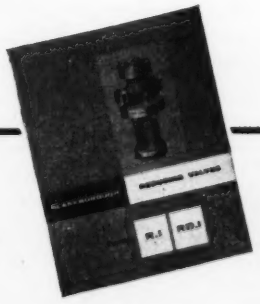

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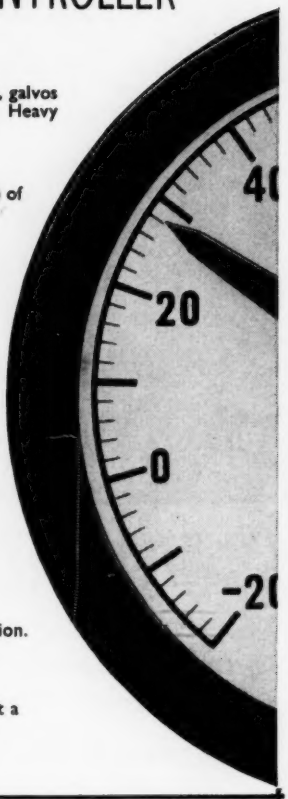

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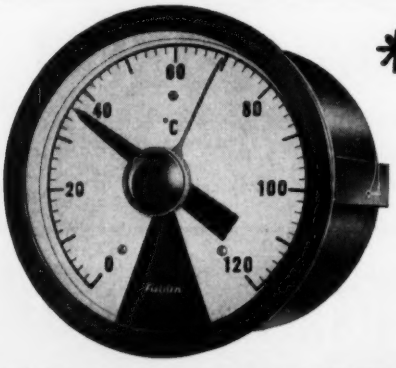

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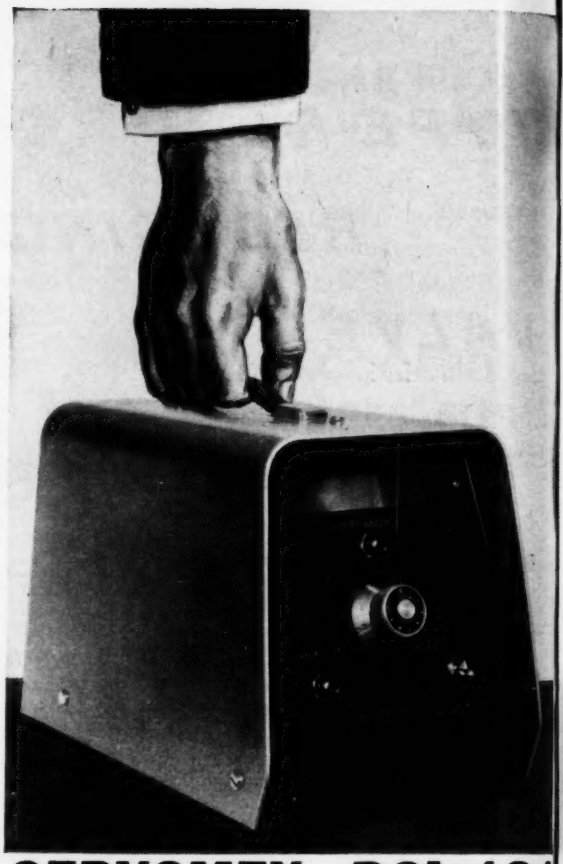

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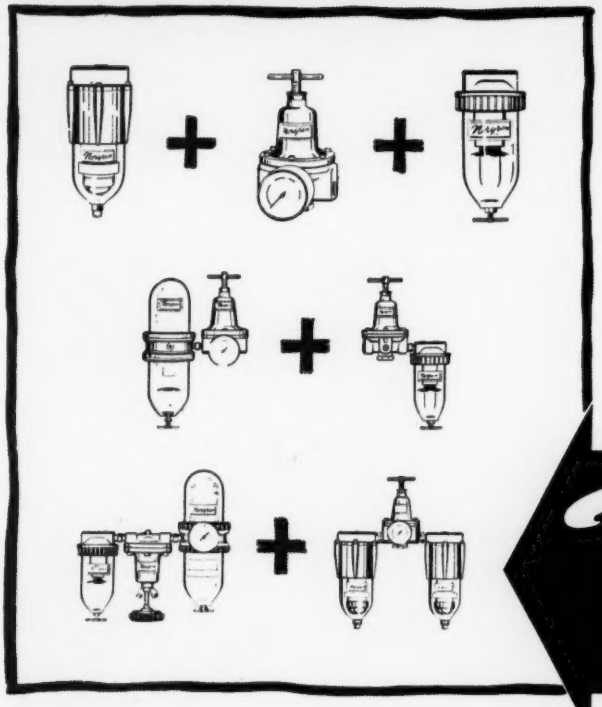

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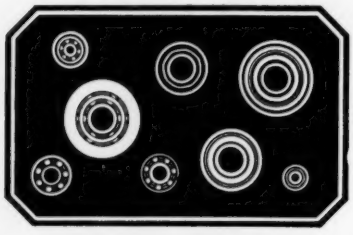

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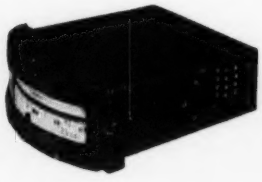
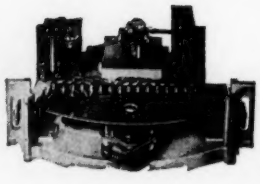
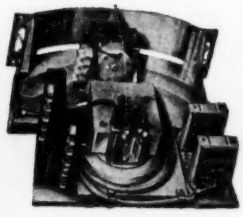


Thermocouple Pyrometer (5-point)



Interior of Electrical Resistance Thermometer (4-point)

Pyrometer Controller with red and green signal lamps



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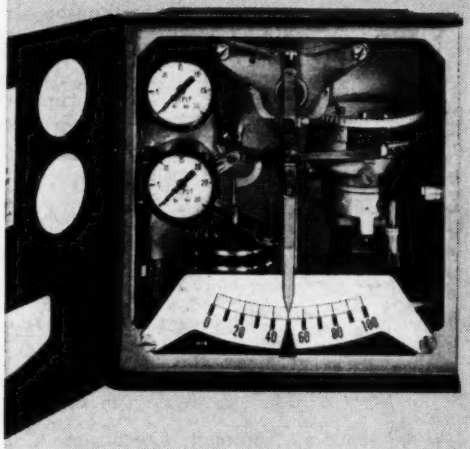

NEW
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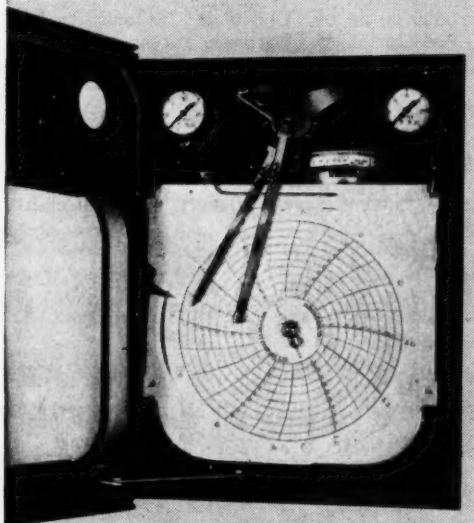

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PCD4

INSTRUMENT PRACTICE

COMMENTARY

Pneumatics Versus Electronics

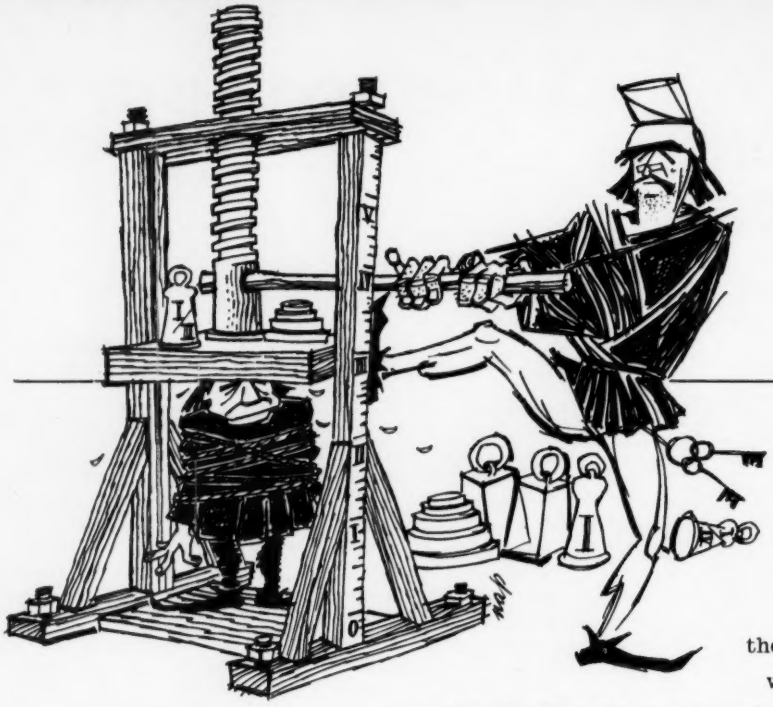
The enormous development in electronic engineering since the end of the war could hardly fail to have some significant effect on measurement and control techniques. Yet even now, the number of firms manufacturing electronic control systems is not large either in this country or in the United States. To dislodge pneumatic techniques entirely from industrial process control is a major task rendered more difficult by the fact that pneumatic process controllers are adequate for many processes and will remain adequate for some time to come. Even so, an industry cannot rest on its laurels in an age when some fresh development is announced every few months. The advancement of electronic computer applications, both digital and analogue, must have given those with pneumatic interests considerable food for thought. The challenge has not been entirely disregarded, for in the past two years we have had a number of articles in the technical press on pneumatic analogue computers. In any case, this is not surprising, since simple computing elements have been employed in pneumatic control systems for some time. These have been able to add, subtract, integrate, differentiate and perform other computing functions. The arrangement of these standard devices to form an analogue computer was a logical step and one article, selected at random, indicates how this may be carried out. The article is " Using Pneumatic Analogue Computing Elements for Control " by C. L. Mamzic in *Control Engineering*, April, 1961. Here is described a system which can add, subtract, invert, multiply, divide, differentiate, integrate, extract square roots, generate functions and produce AND, OR, NOT and MEMORY actions. This article is descriptive only and does not comment on the relation of pneumatic analogue computers to their electronic counterparts. A very recent contribution, however, to the *I.S.A. Journal* for September, 1961, is somewhat forthright in this respect. The paper is entitled " A Pneumatic Computer for Process Control—Will it spearhead a swing back to pneumatics? " and the author is D. W. Chapin, a control systems project engineer of a company newly entering the process control field. The company in question has made a detailed market research into the control needs of United States industry and in the introductory paragraph of the paper is the phrase " Most control engineers think the next logical step in process automation will be control by small special purpose analogue computers ".

Presumably this is what the market survey has shown, in spite of the bigger computers now installed in the United States, and, if so, the company is entirely logical in acting on the information. The real significance of their action, however, is that for their first entry into industrial instrumentation they have decided to produce a *pneumatic* computer. This is designed completely as a system and not as an arrangement of existing parts. " We decided that our computer would be pneumatic-mechanical because 90% to 95% of existing controllers in the petroleum and chemical industries are pneumatic and use the 3 to 15 p.s.i. air pressure signal." But the firm is not unmindful of progress in various instrument fields, particularly the analytical one in which a number of equipments produce electrical signals, and the computer can accept electrical signals without external conversion. A factor, by no means the least one, in favour of electronic analogue computers is the module arrangement where one unit may easily be replaced by another if a fault develops. The module concept has been incorporated into the pneumatic computer under discussion and the repetitious use of common parts has been introduced to lower costs and to allow flexibility to changing process requirements. Both in the *I.S.A.* paper and the *Control Engineering* article studies are presented of actual applications of pneumatic computers to industrial processes which indicate the manner in which the subject is being handled.

Whilst American developments have been considered, United States is by no means the only country giving attention to pneumatic computers. It is known that the problem is receiving investigation in this country and the Russians have been interested for some time.

Whilst appreciating the serious nature of the effort in developing pneumatic computers, one wonders whether the challenge has not been left too late, particularly since some very attractive compact electronic analogue computers with wide capabilities have appeared on the market within the last year. The argument that installing an electronic computer in a completely pneumatic control system needs electro-pneumatic converters, whilst of significance, is not necessarily an over-riding one. The real deciding factor may lie in the flexibility of the electronic analogue computer in *off*-line studies.

Circle 345 for further information



pressure control

In the middle ages the application of pressure was the accepted method of dealing with any prisoner who was "mute of malice" or just plain unco-operative. When told to "talk or else" the wise prisoner usually preferred talking to the "or else". Pressure control was necessarily in a somewhat rudimentary stage depending on the sense of humour of the gaoler. This was known as the inhuman element. Today, DELTA can supply pressure control instruments for controlling almost any kind of pressure, although H.M. Prisons are one of the very few possible users from which enquiries have not so far been received.

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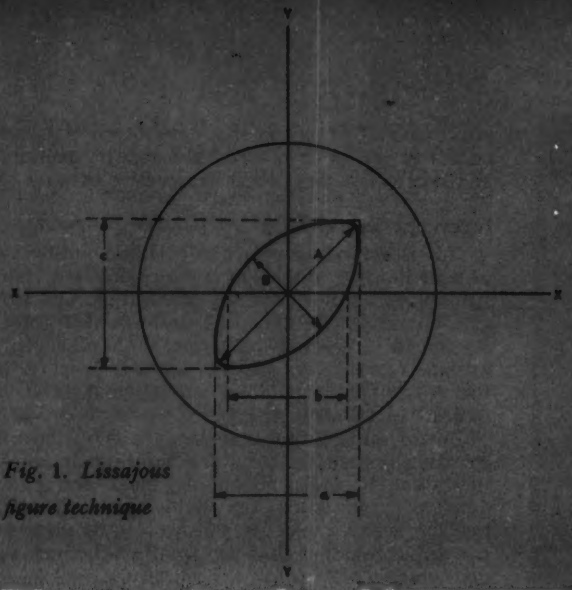


Fig. 1. Lissajous figure technique

A Survey of Phase Angle Measurement Techniques

By D. S. TILLEY*

WITH the increasing use of closed loop control systems, a great deal of emphasis is being placed upon phase angle and amplitude measurements. No longer is it possible to use rule of thumb methods to determine system behaviour; especially as in general systems are tending to become more and more complex.

Methods of amplitude measurements of use down to reasonably low frequencies present few problems, as instruments to carry out the necessary functions are usually available in most laboratories. It is the purpose of this article to summarise various techniques used in the measurement of phase angle.

Certain of the techniques described will measure phase angle only, others are capable of amplitude indication as well. Also some methods give phase angle direct whilst others require some form of computation process before the required result is obtained. Due to these factors it is difficult to assess which method is superior, and the potential user will have to judge for himself which technique suits a particular problem, bearing in mind the accuracy requirements.

Cathode Ray Tube Systems

Methods employing cathode ray tubes are probably the most widely used methods of all, although no great accuracy can be claimed and the presence of a large harmonic content can make measurements extremely difficult.

(*a*) *Lissajous Figure Technique*

Of all methods this is probably the simplest to employ, the reference voltage is applied to the X plates and the signal voltage is applied to the Y plates, thus producing a 1 : 1 Lissajous figure. The display has two special cases of a circle for 90° and 270° and of a straight line for 0° and 180°. At intermediate phase angles the display is of elliptical form.

The method can be extended by the use of X and Y amplifiers having identical phase characteristics such that both traces can be adjusted for equality of deflection and it is possible to compute the phase angle by taking measurements of the elliptical display. Referring to Fig. 1, $\sin\phi = \frac{b}{a}$ or $\sin\phi = \frac{AB}{ac}$

The accuracy of the method will depend upon the amount of harmonics present in either voltage and the thickness of the trace.[1]

(*b*) *Double Beam Oscilloscope Technique*

In this method the two voltages (reference and signal) are separately displayed on each beam and once again by measurement and computation it is possible to determine the phase angle.

It is essential with this method that the amplifiers associated with each beam should have identical phase characteristics, and for this reason a switched beam type of instrument is to be preferred.

(*c*) *Cathode Ray Tube as a Detector*

Both of the above methods can be enhanced by the use of a calibrated phase shifter in one of the channels. By means of such a device the display can be adjusted

* Service Development Engineer, Muirhead & Co. Ltd.

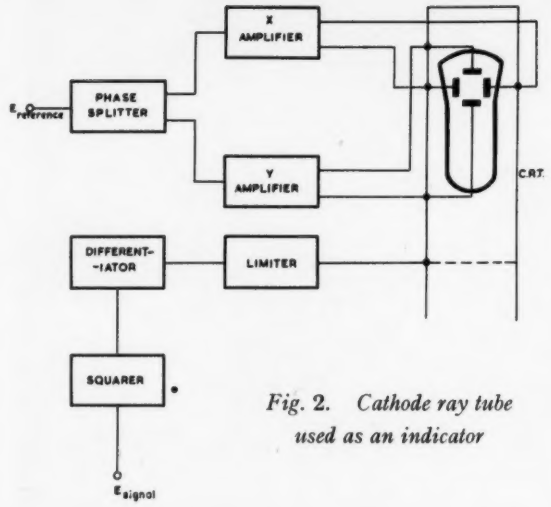


Fig. 2. Cathode ray tube used as an indicator

for a straight line pattern in method (a) or superimposition in method (b) and the phase angle read off direct from the phase shifter setting.

A further refinement is to employ an amplitude control in one channel and by the correct use of such a control perfect superimposition can be obtained in method (b). If this technique is adopted then a reasonable amount of harmonic and noise content can be tolerated in either channel.

(*d*) *Cathode Ray Tube as a Direct Reading Indicator*[2]

This technique employs the method normally associated with frequency comparators.

The reference voltage is used to produce a circular trace on the cathode ray tube and the signal voltage, after shaping and limiting, is fed to the grid of the tube so as to extinguish the trace over a small portion of the circle (Fig. 2).

The phase angle relationship between the reference and signal voltages will determine the position of the " break " in the circle, and the angle can be read off direct from a calibrated graticule mounted on the face of the tube.

Counting Systems

This system essentially measures the time elapsed between two events.

When used as a phase measuring device the reference voltage and signal voltage are fed to suitable squaring, limiting and differentiating circuits. The reference pulse is made to operate a gate circuit ON and the signal pulse to operate the gate circuit OFF. During the gate ON period a frequency much higher than the signal frequency (known as a " clock " frequency) is fed to an electronic counter, and from the displayed count and a knowledge of the signal/clock frequency ratio the phase angle can be computed.

A refinement to this system is to make the " clock " frequency exactly 360 times the signal frequency when the final count will indicate phase angle direct.

This is an inherently very accurate system, however extreme care has to be taken over the design of the pulse circuits to ensure that the output pulse always occurs at the same point of the input waveform (i.e. at the zero crossing point) irrespective of wave shape.

Intercept System

This is similar in principle to the counting system in that limiting amplifiers are used in both channels. After limiting, both signals are rectified and fed to a gate circuit which allows a current to flow through a d.c. meter only when both signals are positive. The average current through the meter is proportional to the " overlap " of the two signals and as such can indicate phase angle direct.

The advantages of this system are as for those of the counting system; due to the limiting action phase indication is independent of signal and reference amplitude, and within reasonable limits the system is not frequency conscious. However, the presence of harmonics in either channel can affect the limiting and inaccuracies will result.

Phase-sensitive Rectifier Systems

The basic circuit of a phase-sensitive rectifier is given in Fig. 3.

The reference voltage is fed to T_1, the resultant current flow developing equal voltages across R_1 and R_2. The output voltage across R_1 and R_2 is therefore zero.

If now the signal voltage is applied to T_2 then, if the signal and reference are in phase, one diode will be fed with $V_1 + V_2$ and the other diode with $V_1 - V_2$ (where V_1 and V_2 are the peak amplitudes of the reference and signal). The output voltage will now be $2V_2$.

A reversal of sign in either of the two input voltages will result in a reversal in sign of the output.

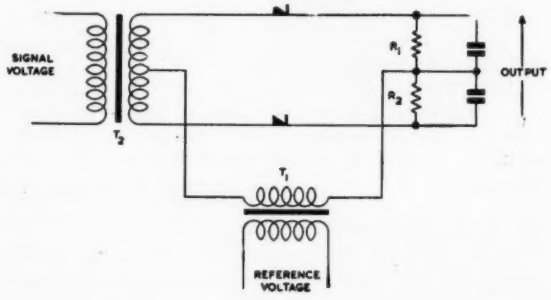
If there is a phase shift of 90° then over a long period the output will average to zero, thus this system is only sensitive to in-phase components. However, if the reference is shifted in phase by 90° then the system will be sensitive to quadrature components.

The accuracy of the system depends upon rectifier characteristics and the harmonic content of the signal waveform. Its frequency range is limited due to the use of transformers.

Computing Systems

There are two main techniques, one involves multiplication and integration processes, and the other depends on the fact that the vector sum of two

Fig. 3. Basic circuit of a phase sensitive detector



alternating voltages is a function of the amplitude of the two voltages and the phase angle between them.

(a) Multiplication and Integration Techniques

1. Dynamometer Wattmeter Method

If a reference voltage is fed to the voltage coil of a conventional dynamometer wattmeter and a current, in phase with the signal voltage, is fed to the current coil, then the torque applied to the moving coil movement will be proportional to the product of the voltage and current in the respective coils.

Since the components are also proportional to the signal and reference voltages the wattmeter indication will be

$$\frac{C}{T}\int_0^T E_{ref} \cdot E_{sig} \cdot dt$$

where T is very long compared with the periodic time and C is a constant.

When E_{ref} is of the form sin ωt then the resultant indication will be zero when E_{ref} and E_{sig} are in phase (i.e. $E_{sig} = A \sin \omega t$). If now $E_{sig} = A \sin (\omega t + \phi)$ the resultant indication will be proportional to cos ϕ, and thus the phase angle (ϕ) can be evaluated.

A disadvantage of this system is that if measurements of phase angle are to be made over a wide frequency range then it is necessary to maintain E_{ref} and E_{sig} at a constant level.

This disadvantage can be overcome by the use of a second dynamometer wattmeter (Fig. 4) which obtains its reference voltage via a 90° phase shifter. The current coil is connected in series with the current coil of the original wattmeter.

The resultant indication of the second wattmeter for a constant E_{sig} is proportional to sin ϕ, and for a varying amplitude signal but constant phase angle wattmeter (1) will indicate A cos ϕ and wattmeter (2) A sin ϕ, where A is the amplitude. Thus the resolved components of the signal voltage vector are indicated on the two meters.

2. Thermocouple Wattmeter System

A disadvantage of the above system is a relatively high power consumption and a restricted frequency range. By the use of vacuum junction thermocouples connected in a bridge configuration a more versatile instrument is obtained. (See Fig. 5.)

It can be shown that the indication of the moving coil meter is given by

$$C \int I_{ref}\, I_{sig}\, dt$$

which is similar to the expression for the indication of a dynamometer wattmeter.

Commercial instruments are available utilising this system, the advantages being (a) a wide frequency range (0·1 c/s to 20 kc/s), (b) good rejection of noise and harmonic components and (c) resonably good accuracy (±2% of full scale) of the resolved components.

3. Electronic Method (see Fig. 6)

The basic method upon which the above wattmeter system depended was to multiply the reference voltage by the signal voltage and then integrate the product. These mathematical processes can be carried out

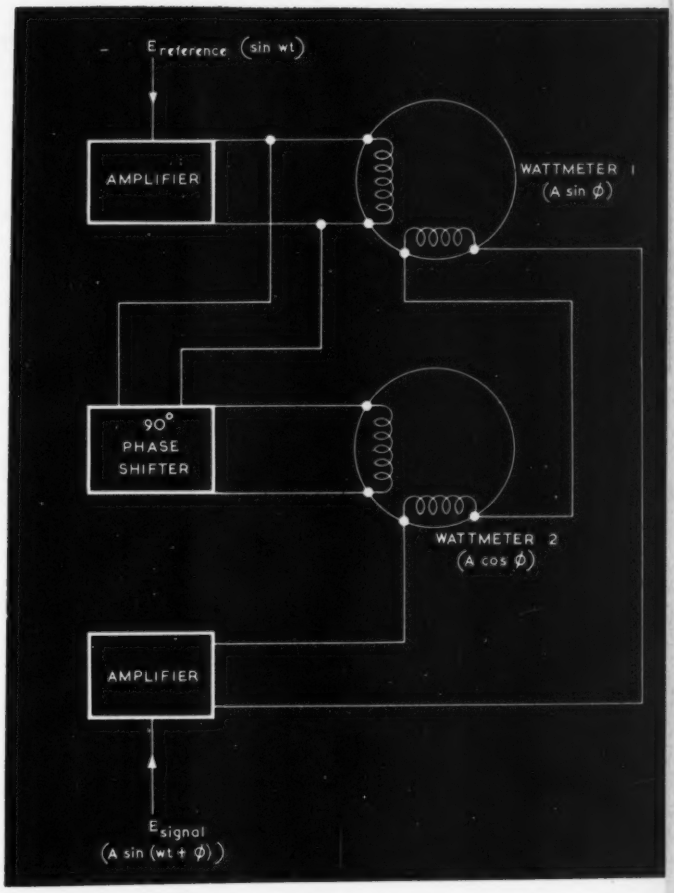
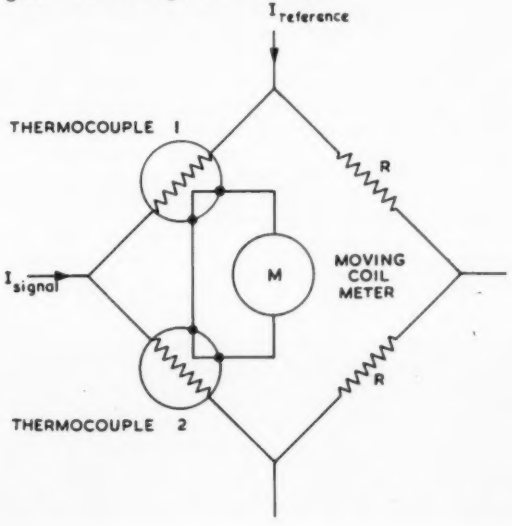


Fig. 4. Dynamometer wattmeter method using two dynamometers

Fig. 5. Thermocouple wattmeter system



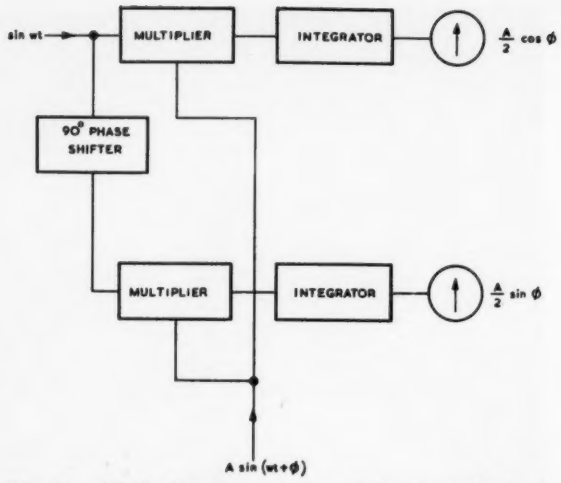


Fig. 6. Block diagram showing electronic method of phase angle determination

electronically using analogue computer techniques.

If the reference voltage is sin ωt and the signal voltage A sin (ωt + φ) then

$$\sin \omega t . A \sin (\omega t + \phi) = -\frac{A}{2} (\cos (2\omega t + \phi) + \cos \phi)$$

Similarly if the reference voltage is shifted in phase by 90° to be cos ωt and once again multiplied by the signal voltage

$$\cos \omega t . A \sin (\omega t + \phi) = \frac{A}{2} (\sin (2\omega t + \phi) + \sin \phi)$$

Thus by two multiplication processes two outputs are available, one containing $\frac{A}{2}\cos\phi$ and the other containing $\frac{A}{2}\sin\phi$, the in-phase and quadrature components respectively. By filtering it is possible to remove the components of 2ωt, however filtering at low frequencies tends to be rather impracticable.

If now both outputs are integrated over one cycle of ωt then all components of 2ωt will equate to zero and a filtering effect will have been accomplished.

There is theoretically no low frequency limit to this system, but integration at very low frequencies is not easy to achieve. However, instruments employing this technique are commercially available with low frequency limits lower than 0·01 c/s[3].

(b) Vector Addition Technique

Referring to vector diagram Fig. 7, OA and OB represent the two voltages, OB being the reference, and φ the phase angle between them, OA and OB are of equal amplitude and OC is the resultant.

From Fig. 7 it can be seen that

$$OD = DC = \frac{OC}{2} \text{ and } A\hat{O}D = \frac{\phi}{2}$$

since the triangle ODA is right angled

$$OD = OA \cos\frac{\phi}{2} = \frac{OC}{2}$$

therefore

$$OC = 2.OA \cos\frac{\phi}{2}$$

If the resultant, OC, is displayed on a meter and both reference and signal voltages are adjusted to be half full scale, then the system is capable of giving phase angle direct from 0° to 180° (0° being at full scale). However, the meter scale shape becomes extremely cramped between 90° and 180°, due to the cosine law, and the reading accuracy will suffer.

A much more linear scale shape is obtained if the meter is made to indicate 90° full scale with zero reading corresponding to 0°.

To achieve this, when measuring angles in the first or fourth quadrant, the reference voltage is fed to the summing point via a sign changer and the two levels are set to be 0·707 times full scale.

The vector diagram will now be as Fig. 8, and it can be seen that the resultant, OC, will be

$$OC = 2\ (0{\cdot}707 \text{ E f.s.d.}) \cos\frac{\phi}{2}$$

Therefore by use of a switched sign changer it is possible to measure phase angles over 0—360° in quadrant steps.

There is bound to be a certain amount of ambiguity with the system as it stands as, for example, the same meter indication will be obtained at say 50° and 310°. However, by switching in temporarily a fixed phase shift into either channel it is possible to determine the correct quadrant by observing the direction of the change in meter deflection. There is nothing critical about the fixed phase shift as its only requirement is to produce a change of deflection that is easily determined.

This system is susceptible to harmonics, about 5% being normally tolerable for good accuracy, but by employing a filter it is possible to carry out phase measurements when the harmonics present amount to as much as 100%. One of the criticisms levelled at this type of system is that if a filter is used to minimise the effect of harmonics, then its phase characteristic must be accurately known. Referring to Fig. 9 it can be seen that by placing the filter after the adding stage no adverse effect on phase measuring accuracy occurs.

Commercially available instruments using this technique cover frequency ranges of from 0·25 c/s to 10 kc/s and 2 c/s to 100 kc/s, with an accuracy of ±1°. With these instruments it is possible to " scale expand "

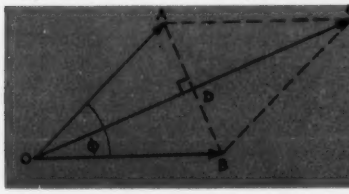


Fig. 7. Vector addition (0—180°) diagram

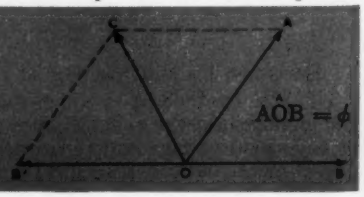


Fig. 8. Vector addition (0—90°) diagram

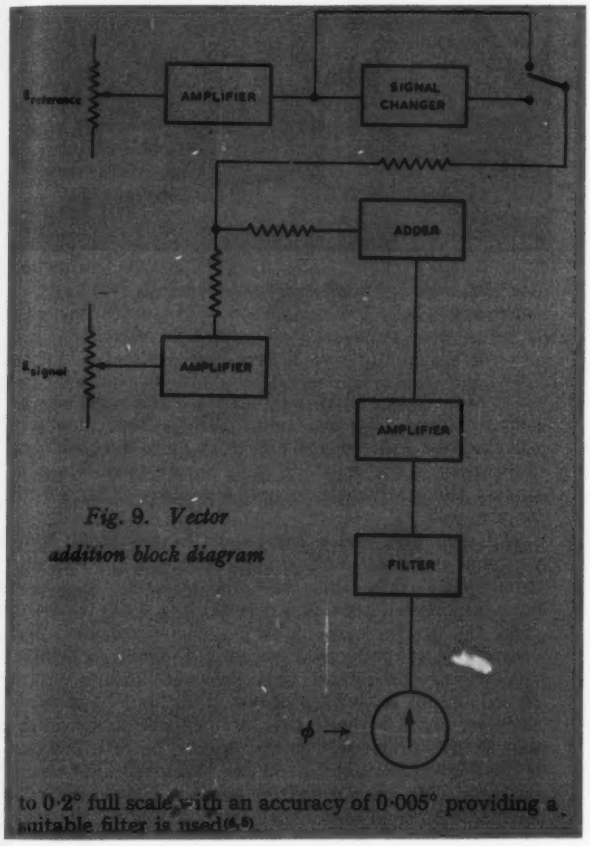


Fig. 9. Vector addition block diagram

to 0·2° full scale with an accuracy of 0·005° providing a suitable filter is used[4,5]

Conclusions

As stated in the introduction, it is difficult to compare directly the methods described in this article, however for versatility and accuracy the computing systems are probably superior.

In some cases it is difficult to choose between the multiplication/integration methods and the vector addition method. One point that will be obvious is that the multiplication/integration methods will in general require the use of a special generator providing E_{ref} and $E_{ref} + 90°$, and that this requirement means that measurements will invariably have to be taken with reference to the input of the system under test. Also the system does not indicate phase angle direct and computation is necessary to obtain the required phase angle.

The vector addition system is capable of measuring phase angle between any two points in a system, and virtually any generator will suffice. The phase angle is indicated directly, this more than compensating for the slight increase in operating procedure requirements.

Acknowledgements

The author wishes to thank the directors of Muirhead & Co. Ltd. for permission to publish this article.

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BOOK REVIEWS

Annual Review in Automatic Programming. *Volume* 2. *Edited by R. H. Goodman. Pergamon Press Ltd.*, 1961. 394 *pages.* 70s. 0*d.*

This book, the second in the series, is an attempt to exhibit current trends in the automatic programming of digital computers by presenting a sample collection of original papers on the subject. It will appeal, therefore, to the student who is well acquainted already with much of the material in this book (e.g. Algol 60, Fact, Cobol, Uncol) rather than to the person looking for an introduction to the subject, who would be liable to leave the volume with a (not completely unjustified) confused picture of the state of the art, as exemplified in particular by the opposing views on Cobol which are presented.

Some of the deficiencies of the first volume have been overcome—the papers are more recent and are more representative of work in Europe and the U.S.A. However, as the editor admits, this type of presentation inevitably has its shortcomings, in particular due to the incomplete treatment of the subject, and one looks in vain for discussion of list processing and heuristic programming, both of which have been exciting considerable interest and activity for some time. In the absence of such important topics it would have been helpful to the reader to have had an authoritative introduction to the book, as he, the reader, in order to put the individual contributions into proper perspective, must also be very familiar with the subject.

A. F. MANN

Theory of Automatic Control. *By M. A. Aizerman. Pergamon Press Ltd. September*, 1961. *Approx.* 550 *pp.* 63/-.

Translated from the Russian, this book, which is the second enlarged and revised edition, presents certain aspects of the theory of automatic control, particular attention being focused on the analysis of practical control systems. The author describes controllers used in conventional automatic control schemes and in process control installations, together with the important features of the plane method of analysis. Useful work on structural stability is included and a new method is presented for graphically determining the transient response of high order systems.

(*Continued on page* 1544)

Progress at Cambridge

The Research Laboratories of the Cambridge Instrument Co.

A NEW instrument assembly wing was opened at the Cambridge works of the Cambridge Instrument Co. Ltd. on 23rd October. The opening ceremony was performed by Sir Keith Joseph, Bt., M.P., Minister of State at the Board of Trade.

The New Building

A feature of the new wing is its two raised stories with the ground-level car park beneath. It blends with the research laboratory building—opened two years ago—to which it has been planned as a logical architectural extension. The two raised stories provide a working area of approximately 15,000 square feet and are joined at one end to the research laboratories and, at the other, by means of a two-storey link block, to existing works buildings.

Two-thirds of the first floor area is occupied by offices, the other third being taken up by the micro-analyser production department. The whole of the second floor area is used as a workshop for instrument assembly and testing, both production departments being connected by air-locks to a link block containing stairs and a lift.

An Enviable Export Record

In addition to speeches made by the Minister and the managing director of the Cambridge Instrument Co. Ltd., Mr. H. C. Pritchard, the chairman of the company, Mr. P. Dunsheath, gave a welcoming address. He quoted some impressive figures for the efforts of the firm relative to foreign trade. The relevant parts of his speech are given below.

" We are proud to recall the great names in science who have been closely associated with the company, and the outstanding contributions to scientific progress which have been made by us in so many cases, where the main result has been the making available of discoveries and inventions over a wide range of industry and to many scientists.

One of the latest of these outstanding successes is the Microscan, an advance likely to have an impact comparable with that of the electron microscope. Although it is only two years ago that we first made the instrument, our workshops are crowded with components being made and assembled for shipping to leading firms in this country and abroad. The first production instrument was installed in May of last year, and, during that same year, three went to the United States. By the end of this year another five will cross the Atlantic and four more go to the continent of Europe. This one item will, in one year, bring to Britain the equivalent of half a million dollars, with more to follow.

If I may give you a few export figures I can show you that we have a record to be proud of. Taking three years only—in 1959 the company's export business totalled close on £360,000. In 1960 it rose to £525,000, an increase of 46%. If we continue this year, as we are going now, we should exceed £600,000.

You will understand that this outstanding export record cannot have been obtained without hard work, and even more without a real live export policy on the part of the company. In this sphere, enterprise again is just as important as on the scientific side of our business. We are not content to sit at home and write letters to our many friends all over the world. We both encourage them to come and see us and we ourselves go out and ascertain the prospects at first hand. Senior members of the company, including directors, are finding out at first hand the opportunities, both east and west. We believe in the personal contact. The languages at the command of our representatives, and the friendships they have formed in all quarters of the globe, are legion. We are, in addition, formally represented on the spot in some 30 countries.

I should now like to announce an important arrangement overseas which we have just concluded. In Milan, ten days ago, I had the pleasure of signing an agreement with Instrumenti di Misura, C.G.S., to form a new company, Cambridge-C.G.S., to build a factory near Naples.

The issued capital of the new company, in which each parent organisation has an equal interest, will be 3,000,000,000 lire (£1,740,000), official permission having been given for the remittance of the Cambridge contribution.

' C.G.S.,' which has its origins in a company founded over 65 years ago by Camillo Olivetti, employs over 1,500 people and manufactures a wide range of electrical measuring equipment for industrial and laboratory use, including switchboard and precision indicators and recorders, instrument transformers of all types, and supply meters. It has a long tradition of bold and inventive design and has always fostered, as we have, close relations with many distinguished

electrical engineers and scientists, including Vallauri, Campos, Nobili, Semenza and Barbagelata.

I should like to emphasise one very important aspect of the Italian arrangement. Cambridge-C.G.S. will manufacture indicating, recording and controlling instruments based on Cambridge designs which will, where necessary, be adapted to meet the requirements of the Italian and neighbouring markets. One important result of this will be increased export potential through making it possible for us to sell abroad the complex measuring equipments which go with the indicators and recorders.

The board of the new Italian company will have three directors from this company and three from our Italian friends, and immediate steps are being taken to select personnel for interchange of ideas and for starting up manufacture under temporary conditions until the new factory is built with all speed.

The distribution function will be in the hands of C.G.S. and Soc. Ing. Taragni and Co., the latter having for many years acted as agents for Cambridge in Italy.

I should perhaps mention that the company now being formed is by no means our first venture of its kind. We are perhaps unique in the instrument industry in that we established, many years ago, a company in America which not only assists us by obtaining valuable orders from that continent, but additionally brings back each year a return in dollars exceeding the total financial investment made in it."

New Developments

Some new developments, on which information was available at the opening of the new wing, are described below:

Combustion Efficiency Meter

This instrument records an index of combustion efficiency based on the chemical composition and temperature of the flue gases and the type of fuel used. The prototype model is at present installed for trial in a power station.

The oxygen content of the flue gases is measured by a magnetic oxygen meter and the temperature by thermocouples. Small quantities of combustible gases that might otherwise have a considerable effect upon the index are determined by a katharometer. These three values are fed into a computer circuit together with the predetermined calorific value and carbon and hydrogen contents of the fuel. A four point recorder is used to give continuous records of oxygen content (0-10%), temperature (0-500°F), combustible gas content (0-1%) and combustion efficiency (75-100%).

The need for such equipment was suggested by the North Western Division of the Central Electricity Generating Board, which is co-operating fully in the testing of the outfit.

Polarography Applied to Automatic Analysis

A Cambridge Univector polarograph is used in conjunction with the automatic sampling apparatus designed and marketed by Messrs. Baird and Tatlock (London) Ltd. The Univector polarograph is not to be confused with the derivative type of polarograph although the records it produces are superficially similar in appearance. In the Univector, an a.c. voltage is applied to a mercury dropping electrode in series with a variable d.c. voltage, the resulting record being dependent upon the a.c. impedance of the electrode.

In the B.T.L.–Cambridge equipment a sample is taken from the process stream, diluted if necessary, and the supporting electrolyte added. After the solution has been degassed with hydrogen the potential applied to the electrode is varied over an appropriate range and the a.c. polarogram is traced out on the chart of a recorder, the result appearing as a sharp peak rising from a horizontal line. The most suitable concentrations for measuring are between one and ten milligrams per litre.

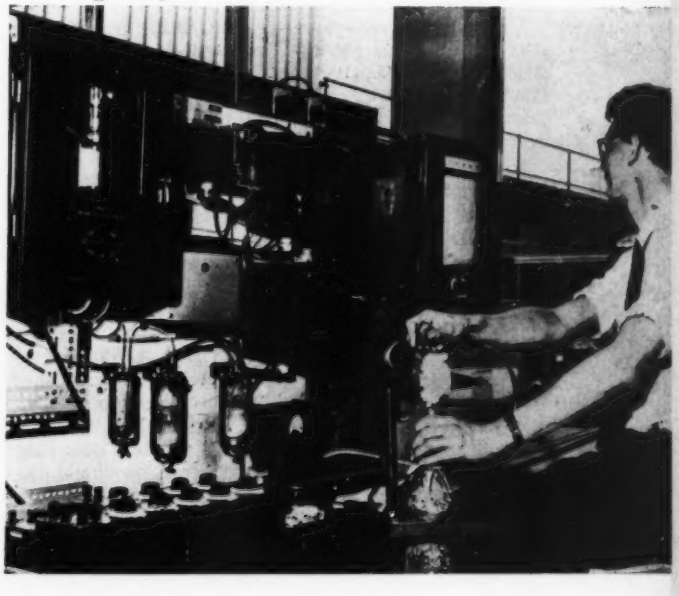
The apparatus enables the process control chemist and instrument engineer to apply polarography to the automatic monitoring of processes, examination of effluents, etc. It is very sensitive and allows many substances to be measured in the presence of much larger concentrations of others which have a different reduction potential.

Electro-pneumatic Converter

This unit is designed to convert an electrical signal into a proportional air pressure that is suitable for the operation of pneumatic regulating units or for feeding into a pneumatic controller.

The converter is fundamentally a force-balance unit consisting of a beam with one end attached to a coil moving in a strong magnetic field and the other end connected to a Bourdon tube. The signal to be converted is fed into the coil as a small direct current, which tends to move the beam and to cause unbalance. The unbalance is detected by means of a flapper/nozzle system, the nozzle back pressure being fed back

Research Department: experimental work on the combustion efficiency meter



Part of the Microanalyser Department

via a pneumatic relay to the Bourdon tube, which moves the beam and re-establishes balance. Since both the force due to the coil and that due to the Bourdon tube are proportional to the signals producing them, the output pressure is proportional to the input current.

Taut-suspension Galvanometer

This novel moving-coil galvanometer combines the best features of pivoted and suspended-coil movements. The coil is suspended by short metal bands under tension and moves in a strong radial field provided by a central permanent magnet with an external cylindrical pole-piece. The metal bands, which are carefully designed to eliminate fatigue, also provide the movement with control force and electrical connection.

The taut band suspension has approximately the same torsional characteristic as the bifilar-loop type of suspension, but it is very much stronger and capable of carrying higher currents. Tests show that the suspension can withstand shocks of up to 100 *g* in any plane without loss of performance.

The complete movement is only $1\frac{3}{4}$ in. in diameter. This type of construction gives a high torque/weight ratio and flux density with very low flux leakage. The outer cylindrical pole-piece effectively screens the movement from all external fields and also protects it from mechanical interference.

Development Work on X-ray Microanalysis

Research and development work on X-ray microanalysis and allied techniques is continuous, and, where necessary, the standard Cambridge Microscan X-ray analyser is being modified or supplemented in order to increase its versatility.

The need for slow scan rates—down to one micron a minute—has been established by Dr. D. A. Melford, of Tube Investments Research Laboratories, and other workers. This has resulted in the development of a slow-scan generator capable of causing the Microscan probe to scan at this speed. It is a separate unit that can be used either to generate an ultra-slow single line scan or to produce a slow raster in conjunction with the existing Microscan line time-base circuit, and very little modification to existing Microscan analysers is necessary before a generator can be fitted.

Experimental work is also directed at a method of extending the range of the instrument down to low atomic numbers. In addition, the performance of various types of e.h.t. equipment is being assessed (work involving the development of suitable measuring techniques and the construction of specialised test equipment), and attention is being paid to the use of c.r.t. storage systems, probe current integration, and various types of spectrometer.

Experimental Scanning Reflection Electron Microscope

This microscope is being developed primarily for the examination of specimens that have comparatively rough surfaces or characteristics that preclude the use of extraction replica techniques. It is intended to be largely complementary to the transmission electron microscope and other applications are likely to include the examination of delicate fibres and the study of voltage gradients across semiconductor junctions and similar phenomena.

In the scanning microscope a finely focused beam of electrons is made to scan an area on the surface of a solid specimen. The back-scatter of low energy electrons thus produced is detected by the phosphor of a scintillation counter, the output of which is amplified and used to modulate the brightness of beams scanning two cathode ray tube screens in synchronism with the electron beam scanning the specimen. The pictures thus formed on the screens provide a record of the variation in certain properties of the specimen surface. One of the screens is fitted with a camera so that the specimen can be observed and photographed simultaneously.

The new microscope utilises many of the principles investigated in some detail at the Cavendish Laboratory and the Cambridge University Engineering Department. The experimental instrument, now in course of assembly, employs several basic units of the standard Microscan X-ray analyser. Modifications to these units, coupled with the addition of suitable ancillaries are expected to provide the high electron resolution required for a reflection electron microscope.

Safety Fittings for Compressed Air Installations

THE use of compressed air grows each year as more and more applications are found for it. To help this growth, the British Standards Institution has revised and enlarged B.S. 1123, giving specifications for safety valves, gauges, and other safety fittings for air receivers and compressed air installations.

Although the main provisions of the standard remain unchanged, modifications have been made to secure co-ordination with the 1955 edition of revised B.S. 759—"Valves, gauges, and other safety fittings for application to land boilers and piping installations for and in connection with land boilers." The most important of these modifications is the permissible use of safety valves having an established discharge greater than provided for by the minimum aggregate area formula.

The revision also includes a comprehensive specification covering the requirements for safety valve springs.

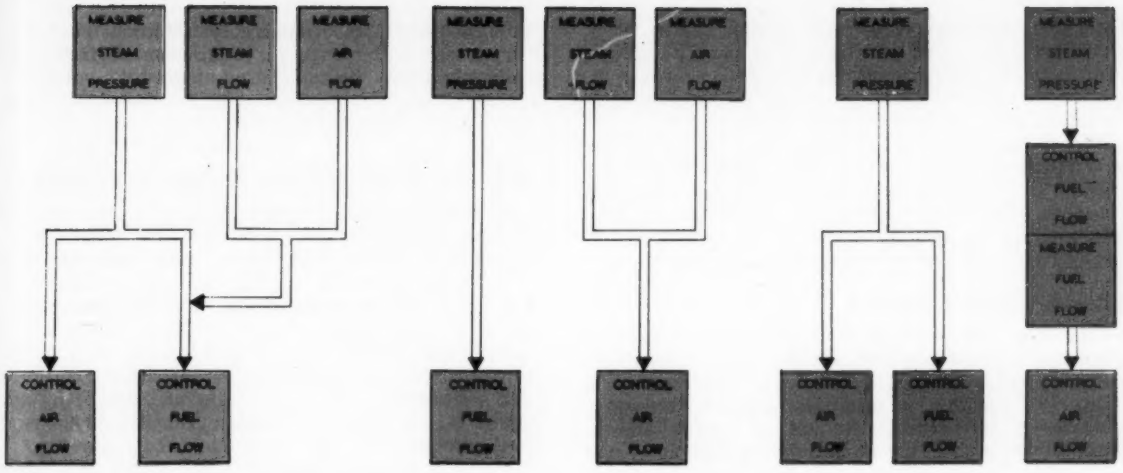


Fig. 1. Four methods of applying control equipment utilising three measured variables: steam flow, steam pressure and air flow

A New Approach to AUTOMATIC COMBUSTION CONTROL

By C. H. COPLEY, B.Sc., A.Inst.P.,* and W. HALL, A.S.M.E.*

IT has now become established practice to use automatic combustion controls on most of the larger industrial boilers as well as on power stations. The gradual change from manual to automatic control owes much to the observations and judgement of boiler operators, as well as to continuous and more precise measurements that are being made. There has now been established an almost standard pattern of control for each individual type of steam raising plant.

Modern performance calls for control systems able to meet changes in load demand with the minimum upset of steam pressure and involving a maximum economy of fuel, labour and maintenance charges.

Whilst there is an almost infinite variety of ways in which control equipment can be applied, it is of interest first to show diagrammatically (Fig. 1) a few of the more popular ways in which the three measured variables—steam flow, steam pressure and air flow are utilised.

Control systems vary widely to suit individual boiler requirements as illustrated in these diagrams. For example, steam pressure may control air flow only; and the fuel flow can be regulated from a separate measurement of air flow. Another possible variation is to employ steam pressure changes to adjust air and

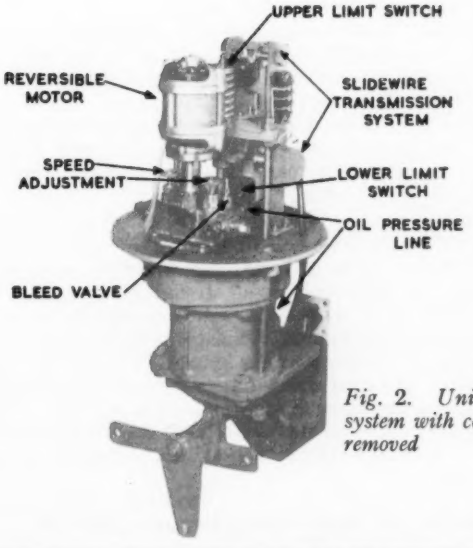


Fig. 2. Unibloc system with cover removed

* Process Control Division, R. B. Pullin & Co. Ltd.

fuel flow simultaneously, with fuel/air ratio as a secondary adjustment to either fuel or air. In the case of boiler feed water regulation it has become apparent that so far the most effective method is to utilise three elements, viz:—steam flow, water flow and boiler level.

It is the purpose of this article to describe in principle a complete system of combustion control already in use on the Continent, which, as well as giving the closeness of control referred to, introduces a new approach as far as this country is concerned to the problems of economic installation and reliability.

Master Pressure Control

The first indication of load change is shown by changes in steam pressure. When demand increases suddenly, additional steam flow results temporarily from the " flashing " of water in the drum; this water contains a considerable amount of energy and is responsible for the " kick " in boiler explosions. With an increase in load, the pressure drops and part of this water turns to steam even without an increase in firing rate, thus helping temporarily to bridge the delay between the demand and the increased firing rate. When the load falls the converse situation occurs, since the higher pressure invoked institutes a compression effect in the drum.

It can therefore be appreciated that the behaviour of steam and water in response to load changes has " a fly-wheel action " on the pressure situation, modifying the effect of load change on the flow. This is fortunate as it works in a favourable direction with both increasing and decreasing loads; and control systems must be capable of taking advantage of this effect in order to assist in an anticipatory action for the reduction of lags in the system.

Fuel/Air Ratio Control

A constant monitor of the fuel/air ratio is of prime importance to efficient combustion control and sufficient air must be available at all times to meet load changes. Problems arise here in obtaining a correct measure of fuel flow, particularly with coal which is difficult to measure. Some systems utilise the measurement of steam flow to regulate input, and this is permissible if the boiler efficiency remains constant over the load range. Where pulverised coal is used, feeder speed or primary air flow can give a good indication of fuel flow.

Furnace Pressure Control

Changing loads and changing air flows mean that furnace pressure will vary. It is therefore necessary for dampers or fans to maintain a slightly negative pressure in the furnace. Whilst it is possible to control the i.d. fan by employing a single element, it has been found better to introduce a second influence into the control, particularly on larger boilers. Air flow or f.d. fan pressure is made to balance the fans and also provide an anticipatory signal of a change in furnace pressure.

Superheated Steam Temperature Control

Final superheated steam temperature control is not only desirable but essential on large boilers associated with the generation of electricity. Methods of control vary greatly with the specific requirements of individual boiler plant, but the application in general involves the measurement of three variables: steam flow, spray water and steam temperature.

A Simple Form of Multi-element Regulation

Summarising the foregoing, and including the case of drum water level control, the *basic* requirements can be made up from a series of five control loops, viz:

1. Load regulation
   (3 elements—steam pressure, steam flow, air flow)
2. Fuel/air ratio
   (2 elements—fuel flow, air flow)
3. Draught
   (2 elements—furnace draught, air flow)
4. Drum water level
   (3 elements—steam flow, water flow, drum level)
5. Superheated steam temperature regulation
   (3 elements—steam flow, spray water flow, final steam temperature)

Whilst these five control loops are generally covered by most instrument companies in this country specialising in boiler control, it is considered in many quarters that there is room for improvement, particularly in terms of simplicity, economy and reliability. For example, most of the systems employ combinations of proportional and integral control: many manufacturers do not indulge in the multi-element controls described above because of the ensuing complexity. Again, even where proportional, integral and/or derivative control is used in conjunction with multi-element regulation, redundancy of function will occur, since the different elements involved often themselves introduce integral and derivative factors. For example in a 3-element drum level regulator, the balance between feed water flow and evaporation rate is a measure of the rate of change (i.e. derivative) of the water level.

What is required is a design of controller which lends itself naturally to multi-element operation with very little more complication than occurs with single-element control. A considerable effort has been expended in Italy to achieve such simplification, whilst still maintaining a fine control accuracy; and over the last five years this type of equipment has become thoroughly proven on many different types of boiler. It is now available in England. The excellence of Italian design, which is now universally acknowledged, ensures a simplicity of construction which makes the equipment simple and economic to maintain.

The system to be described (known as the Unibloc System) is centred round a specially designed compact electrohydraulic actuator for valves and damper drive, which is illustrated (with the cover removed) in Fig. 2. This actuator is so designed that:

1. Its maximum speed in either direction can be pre-set on site
2. It can be directly driven in either direction at the maximum rate from any Unibloc controller
3. It can be motored manually, if required, as an alternative to automatic operation
4. The motor is only required to operate when a

corrective signal is received from the controller. The controller consists of:

1. A computing device which counterbalances various forces on a mechanical beam
2. A switching device for operating the electro-hydraulic actuator.

Provision can be made, where necessary, for feed-back from the actuator to provide a further input element (e.g. a derivative component for anticipation) to the controller. Fig. 3 shows a schematic layout of a typical control loop, using three elements for master pressure regulation.

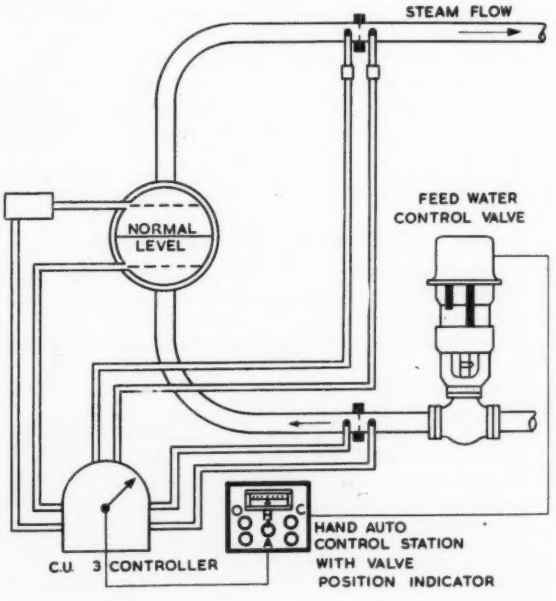
Fig. 4 shows, in principle, the way in which forces are applied in the controller from various elements. As soon as these forces depart from an equilibrium confirmation the electrohydraulic actuator is driven in the appropriate direction. The valve or damper then operates continuously until the process returns to the desired value, at which point contact is discontinued and the supply to the electrohydraulic motor is cut off. The following sections describe, by reference to Fig. 4, how this control system operates in the case of the five combustion regulation loops listed above.

Load Regulation

The load regulator is normally used for the control of combustion air, the balance of the controller maintaining a constant ratio between steam flow (F_1 in Fig. 4) and air flow (F_2). The steam pressure has the function of correcting the air/steam balance if the pressure deviates from the desired value. An adjustment (F_3) is provided so that the balance can be adjusted for individual boiler characteristics.

The effect of the pressure changes themselves on control, because of the corresponding variations caused in steam flow, can be allowed for by means of a further manual pre-set adjustment (F_4) provided. In practice the steam pressure variations are usually small and the setting of the steam/air balance is constant over a wide load range.

Fig. 3. Control loop for master pressure regulation using three elements



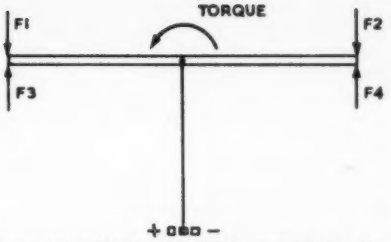


Fig. 4. Forces applied to the controller from various elements

Because of the adjustments provided, it is possible with this system to set the controller to have a fast response to variations in load, or firing rate.

Fuel/Air Ratio Regulation

In this control loop two elements are used to proportion correctly the fuel flow to the combustion air supplied to the boiler. To avoid the use of special devices on the control panel, this controller is designed to enable an initial adjustment to be made so as to obtain the most economical ratio settings over a wide range of boiler loads.

Referring to Fig. 4, torque T and force F_4 are not required. In the case of oil or gas firing, the fuel flow (F_1) is balanced against air flow (F_2) to maintain a constant percentage of excess air regardless of the load changes. This is performed by setting up the balance initially at full load, and then, at half load, introducing an adjustment (F_3) which gives the correct ratio at that loading. With this bias in the system, the full load ratio is re-set to the correct value; finally the half load ratio setting is trimmed once again. The fuel/air ratio will then be automatically adjusted with load under normal operating conditions.

In coal-fired boilers, where it is difficult to measure accurately the fuel input, steam flow is used as an indication of fuel flow. In the case of large pulverised-fuel boilers for power generation, mill differential and MW measurements are used.

Draught Regulation

This control system is required to maintain a small negative pressure in the combustion chamber and utilises two components from which a control signal is generated to the i.d. fan damper. The two components operate on a single balance arm in opposition to each other. Referring to Fig. 4 (without T or F_3), the first element (F_1) tends to keep the furnace suction constant, whilst the air flow (F_2) varies the predetermined depression value with varying load changes of the boiler. The beam of the controller is further balanced by a weight (F_4) operating on a slider which can be positioned to maintain the required depression in the combustion chamber when the two components F_1 and F_2 are in balance.

Drum Level Control

Modern boilers have a high steam release/water ratio and it is therefore essential that special safety precautions should be made to achieve stable control.

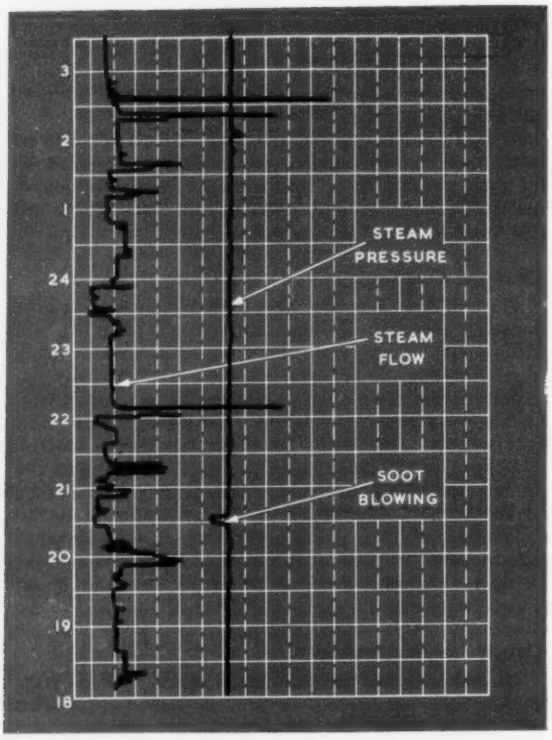
Three-element control is frequently used on large steam generating plants but the costs are normally too high to justify its use on the smaller boilers. This level control has been designed with a view to retaining the improved control facilities of three elements at reduced cost, thus enabling its use to be extended to smaller units.

Referring to Fig. 4 (T not required), the primary control comes from the balance of steam flow (F_1) and water flow (F_2) so that feed water is maintained equal to steam demand. Any variation in feed water flow is detected directly and the control valve is repositioned to maintain the correct water flow, before the effect on level has been detected. Any variation of load is detected immediately from the steam flow, which causes repositioning of the feed water valve. The third element, drum level (F_4) operates as a trimmer and gives the datum from which the desired value can be taken into account.

It is well known that a rapid increase in load demand is accompanied by a rise in water level initially in the boiler drum, often referred to as " swell ". The controller described above is designed to reduce this effect of swell by introducing a bias force F_3 into the system when the controller is first set up. Initially, the device is adjusted to be in the neutral position with the level at the desired value, and the evaporation rate equal to the feed water rate. The bias force F_3 is now introduced into the system and the effect of F_1 reduced accordingly to restore the balance. This means that at the onset of swell, the effect of the evaporation rate is reduced by the factor $\frac{F_3}{(F_1 + F_3)}$. By the time the effect of the change of load has made F_3 relatively high, the increase of level will have come into effect in the control loop.

This system offsets to a great degree the fault in many level control systems, of not counteracting the effect of swell in the early stages of a sudden load increase.

Fig. 5. Steam flow and pressure chart



Superheater Steam Temperature Regulation

This control loop is operated by three elements which direct a corrective signal to a spray water valve or steam recirculating valve.

Operation is similar to that of the load controller, a constant balance between steam flow (F_1 of Fig. 4) and spray water flow (F_2) being maintained, whilst the third element, steam temperature merely operates as a trimmer. The most interesting characteristic is the anticipatory form of control obtained from the steam flow measurement, which is particularly necessary where the process lag of the plant and the slower response of the temperature measuring element could be responsible for poor performance, as is true in more primitive systems.

As an example of the close control available with such a system, Fig. 5 shows a typical steam flow and pressure chart, taken from an installation in a textile mill in Northern Italy. Any irregularities in boiler control can be detected by studying the chart closely.

The record on the left is that of steam flow which varied considerably with a rapidly fluctuating load. The chart reading on the right, for steam pressure, remains constant over the full length of the chart apart from periodic decreases. This provided a true picture of what was happening in the boiler, since these decreases in steam pressure were due to " soot blowing". It will be noticed particularly that the pressure returned to normal as soon as the operation was discontinued.

It should be mentioned that in this particular instance, even with a minimum number of control loops, an analysis of flue gases showed the CO_2 content to be stable between 13½% to 14% over the period shown.

Indicating Tachometers

BRITISH STANDARD (B.S. 3403) for indicating tachometers specifies scale ranges, scales, constructional details, marking, performance and tests for three grades of tachometers, those with a nominal accuracy of ±0·75%; ±1·5% and ±3·0% of the maximum scale value.

Manufacturers who claim that their tachometers conform to the standard must mark the instruments with the standard number. A manufacturer may also be licensed to use the B.S.I. Kite-mark. The presence of this mark is an added assurance that the instrument complies with the requirements of the standard.

Copies of this Standard may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1, price 6s. each. (Postage will be charged extra to non-subscribers.)

Automatic Control and the Application of Linear Theory

By G. V. GREATOREX, A.M.I.E.E., Dipl.Eng., A.Inst.E.,

and B. E. ADAMS, B.Sc.*

Part 2

Analogue Computer Solutions

UNDOUBTEDLY the most powerful tool available to the control engineer is the analogue computer. The capital investment in these machines continues to grow in industry and some very valuable work is being conducted in fields where the equivalent theoretical analysis would be virtually impossible.

Although the programming of an analogue computer tends to be a specialised business, there is no doubt of the benefit to a control systems laboratory of obtaining even the smallest machine.

In recent years several computing centres have been opened in Britain and the Continent where computation time may be hired, along with very skilled teams of programmers and operators, completely equipped to deal with control problems.

The Operational Amplifier

The basic building brick of the analogue computer is the low-drift high-gain d.c. amplifier. By connecting the networks around these it is possible to perform the mathematical operations of integration, differentiation, addition and subtraction.

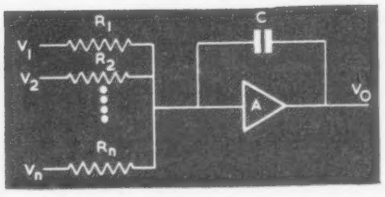


Fig. 9. High gain d.c. amplifier with input resistors and a capacitor in the feedback path

Consider an amplifier with input resistors and a capacitor in the feedback path. (Fig. 9.)

Since the amplifier A is a high-gain unit and its input current is very small, we may write that the sum of all the input currents must be equal to minus the feedback current.

$$\text{i.e.} \quad \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \frac{V_4}{R_4} \cdots \frac{V_n}{R_n} = -\frac{dV_o}{dt} C$$

Clearly, we may connect any number of input resistors and hence produce the electrical analogue of a first-order linear differential equation.

If the output V_o is fed back to the input via a resistor R_o the above equation becomes:

$$\sum_1^n \frac{V_n}{R_n} = -\left(\frac{dV_o}{dt} C + \frac{V_o}{R_o}\right)$$

$$\sum_1^n \frac{V_n}{R_n} = -\left(SV_oC + \frac{V_o}{R_o}\right) \text{ or,}$$

$$-V_o = \sum_1^n \frac{V_n}{R_n}\left(\frac{R_o}{1 + SCR_o}\right)$$

and for one input only, V_q

$$-V_o = V_q \left[\frac{R_o}{R_q}\right]\left[\frac{1}{1 + SCR_o}\right],$$ the familiar "first-order lag" transfer function. A very useful feature of this circuit is the complete independence of time constant on gain, and vice versa.

* English Electric Co. Ltd.

Simple Analogue of Thermocouple in Gas Stream

Consider a thermocouple with a junction temperature of θ_j situated in a gas stream at a temperature θ_g (Fig. 10).

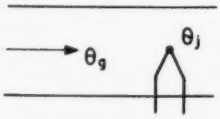


Fig. 10. Thermocouple with junction temperature θ_j situated in a gas stream temperature θ_g

Let M be the mass of the thermocouple junction, C_p the specific heat of the junction and h the heat transfer coefficient from the junction to the gas stream.

Then assuming no heat loss from the junction, heat flow to junction per second = heat stored in junction per second.

$$(\theta_g - \theta_j)\, h = \frac{d\theta_j}{dt}\, MC_p$$

$$\therefore \quad \frac{\theta_j}{\theta_g} = \frac{1}{1 + S\dfrac{MC_p}{h}}$$

An analogue simulation of this equation is shown in Fig. 11.

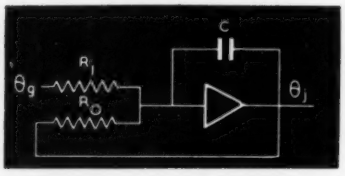


Fig. 11. Analogue simulation of equation

$$\frac{\theta_j}{\theta_g} = \frac{1}{1 + S\dfrac{MC_p}{h}}$$

For this circuit

$$\frac{\theta_j}{\theta_g} = -\frac{R_o}{R_1} \cdot \frac{1}{1 + SR_oC}$$

$$\therefore \quad R_1 = R_o \text{ and } R_oC = \frac{MC_p}{h}$$

The factor $\dfrac{MC_p}{h}$ has the dimensions of seconds and is the effective time constant of the thermocouple, and is usually of the order of 10 milliseconds.

As well as linear differential equations some non-linear differential equations may be simulated by the use of function generators or multipliers, or both.

When dealing with control systems, we are often faced with non-linearities such as dead zone and saturation. These can fairly easily be included in an analogue simulation of the problem by means of function generators.

An Example of the use of an Analogue Computer to verify the accuracy with which the Damping Factor of a Closed-loop System may be predicted using the Root Locus Method

First of all the simple transfer function $\dfrac{1}{(1 + 2S)(1 + 4S)}$ was considered. This was plotted on the root locus diagram and the gain calculated to give a damping factor of 0·2. This was calculated as 25·2.

Fig. 12. Step response of $\dfrac{F_s}{1 + F_s}$

$$F_s = \frac{25{\cdot}2}{(1 + 2S)(1 + 4S)}$$

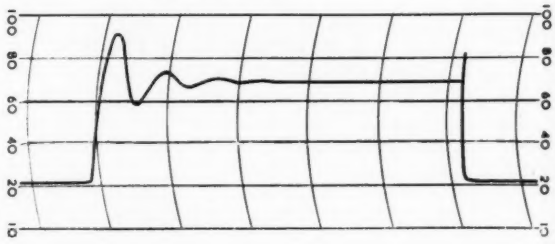
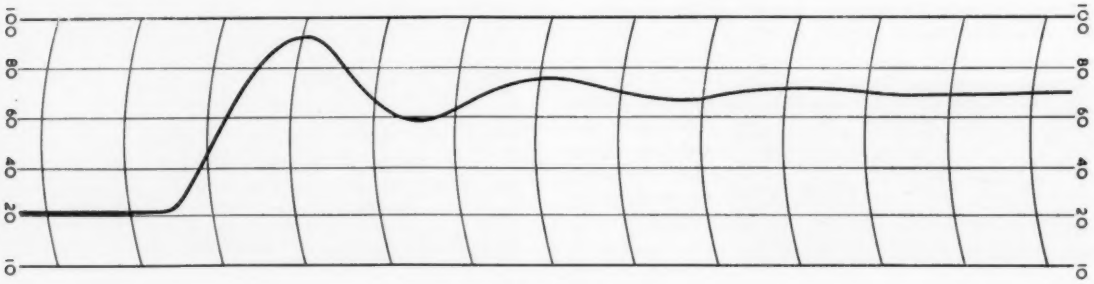


Fig. 13. Step response of $\dfrac{F_s}{1 + F_s}$

$$F_s = \frac{3{\cdot}64}{(1 + 3S)(1 + 4S)(1 + 6S)(1 + 10S)(1 + 20S)}$$

Fig. 14. Step response of $\dfrac{F_s}{1 + F_s}$

$$F_s = \frac{1{\cdot}86}{(1 + 2S)^4}$$



The expression $\frac{25{\cdot}2}{(1+2S)(1+4S)}$ was then set up on an analogue computer and the loop closed with unity gain in the feedback loop. With a recorder monitoring the output a step of voltage was applied to the input. The result, shown in Fig. 12, indicates that the calculation of gain of 25·2 from the root locus plot was approximately correct.

The experiment was repeated for an open-loop expression consisting of 5 simple lags (all different) as shown in Fig. 13, and for four lags (all the same) as shown in Fig. 14.

In all cases a root locus plot gave approximately the right gain for a damping factor of 0·2.

Acknowledgements

The authors wish to acknowledge the English Electric Co. Ltd. for permission to publish this article.

Appendix

Examples of Transfer Function Derivation for Some Common Devices

1. *D.C. Motor Separately Excited*

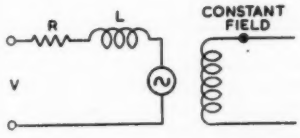


Fig. 15. *Separately excited d.c. motor*

Let L be the armature inductance
R be the armature resistance
J be the armature moment of inertia

Back e.m.f. $= E_b = K_B S\theta$

where K_B = back e.m.f. constant

$$\therefore \quad i = \frac{V - E_b}{R + SL} = \frac{V - K_B S\theta}{R + SL}$$

Also torque $= K_T i$

where K_T = torque constant

$$\therefore \quad K_T i = JS^2\theta$$

$$\text{i.e.} \quad K_T\left(\frac{V - K_B S\theta}{R + SL}\right) = JS^2\theta$$

$$\therefore \quad K_T V = JLS^3\theta + JRS^2\theta + K_T K_B S\theta$$

$$= S\theta[JLS^2 + JRS + K_T K_B]$$

$$\therefore \quad \frac{S\theta}{V} = \frac{K_T}{JLS^2 + JRS + K_T K_B}$$

$$\text{i.e.} \quad \frac{S\theta}{V} = \frac{1}{K_B\left[\frac{JL}{K_T K_B}S^2 + \frac{JR}{K_T K_B}S + 1\right]}$$

$$= \frac{1}{K_B\left[1 + \frac{JR}{K_T K_B}S\left(1 + \frac{L}{R}S\right)\right]}$$

Let $\frac{JR}{K_T K_B} = T_M$

and $\frac{L}{R} = T_E$

then $\frac{S\theta}{V} = \frac{1}{K_B[1 + T_M S(1 + T_E S)]}$

$$\simeq \frac{1}{K_B[(1 + T_M S)(1 + T_E S)]}$$

Since T_M is usually much greater than T_E.

2. *D.C. Generator Driven at Constant Speed and Used as a Power Amplifier*

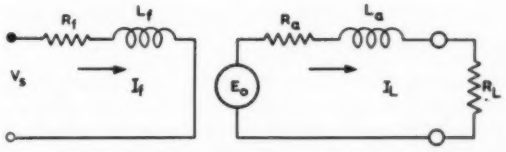


Fig. 16. *D.C. generator used as a power amplifier*

Let the generator characteristics be as shown in Fig 16
Where R_f is the field resistance
L_f is the field inductance
R_a is the armature resistance
and L_a is the armature inductance.

Let E_o be the open circuit output voltage when driven at constant speed.

Then $E_o = K I_f$

$$I_f = \frac{V_s}{R_f + L_f S}$$

$$\therefore \quad E_o = \frac{KV_s}{R_f + L_f S}$$

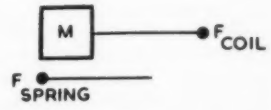
$$I_L = \frac{E_o}{R_a + R_L + L_a S}$$

$$I_L = \frac{KV_s}{(R_f + L_f S)(R_a + R_L + L_a S)}$$

$$= \frac{KV_s}{R_f(R_a + R_L)\left(1 + \frac{L_f}{R_f}S\right)\left(1 + \frac{L_a}{R_a + R_L}S\right)}$$

3. *Transfer Function of a Spring-mounted Vibrator Coil Driving a Mass M*

Fig. 17. *Spring mounted vibrator coil driving a mass M*



Let the mass be moved horizontally in air and assume the motion of the mass to be frictionless.

Then equating the forces shown in Fig. 17

$$F_{Coil} - F_{Spring} = MS^2x$$

i.e. $$F_{Coil} - K_sx = MS^2x$$

where K_s = spring rate.

Let V be the voltage applied to coil
R be the resistance of the coil
L be the instantaneous current

and V_B the back e.m.f. of the coil due to motion in the magnetic field

then $V_B = K_BSx$

where K_B is the back e.m.f. constant

$$\text{and} \quad i = \frac{V - K_BSx}{R}$$

$$F_{Coil} = K_F\, i = \frac{K_F(V - K_BSx)}{R}$$

where K_F is the force constant.

$$\frac{K_F\,(V - K_BSx)}{R} - K_sx = MS^2x$$

$$\therefore \frac{K_FV}{R} = MS^2x + \frac{K_F\,K_B}{R}\,Sx + K_sx$$

$$= x\ (MS^2 + \frac{K_F\,K_B}{R}\,S + K_s)$$

$$\text{and} \quad x = \frac{\dfrac{K_F\,V}{K_s\,R}}{\dfrac{MS^2}{K_s} + \dfrac{K_F\,K_B}{K_s\,R}\,S + 1}$$

This is a second order system of natural frequency

$$= \sqrt{\frac{K_s}{M}}$$

$$\text{and damping factor} = \frac{K_F\,K_B}{2R}\ \frac{1}{\sqrt{MK_s}}$$

(Concluded)

(*Continued from page* 1533)

This work, taken from the author's own lectures in Moscow, is intended for design and control engineers, degree students and post-graduate workers who must understand, analyse and design complex automatic control systems.

Protection Against Radiation. *By John D. Abbott, J. R. A. Lakey, D. J. Mathias. Cassell & Co. Ltd.*, 1961. 235 pages. 25*s.* 0*d.*

The book sets out to be a practical handbook on radiation protection and it is therefore not surprising that operational problems receive more attention than the physics of radiation dosimetry. There is some evidence that the material has been assembled hurriedly and in consequence the subject matter has not been arranged in an entirely logical order. Thus, after a short introduction, Chapter 2 describes briefly the medical effects of radiation before the nature and sources of radiation are discussed in Chapters 3—5. Again the medical care of radiation workers is considered in Chapter 6, but the main sections on personnel protection do not appear until Chapters 10—11. Chapter 8, on maximum permissible doses and levels of radiation, could perhaps have preceded Chapter 7, in which is given a general review of radiation detecting instruments and dosimetry. Chapter 9 contains a useful account of shielding against radiation, and includes tabulated information on the absorption of radiation in various shielding materials.

In addition to the main text there are three Appendices comprising, respectively, a table of isotopes with information on half lives and the energies and types of radiation emitted, a glossary of definitions and a bibliography. There is also a short index.

Chapters 8—11 form nearly half of the text and are the most valuable section of the book. The chapter on maximum permissible doses and levels of radiation contains a detailed statement of the 1958 recommendations of the I.C.R.P. together with a number of explanatory statements made in the following year. This information is not easily accessible elsewhere.

The two chapters on personnel protection show clearly that the authors have had considerable experience of the administration and organisation necessary to operate and control radio-active handling laboratories. A great deal of practical information is presented clearly and authoritatively, including tabulated data on maximum permissible concentrations of many isotopes extracted from the report of I.C.R.P. Committee II, 1959.

On the other hand, Chapters 3 and 7 are less successful. There is a marked difference in purpose between flexible laboratory instruments for the detection and measurement of radio-active decay and simple monitoring instruments and it would have assisted the reader if these types had been considered separately. The distinction between instruments which measure dose and dose-rate is often obscure, especially in the sections on ionisation chamber instruments.

Misleading definitions are given of several physical quantities which are correctly defined elsewhere in the book and there are a number of minor textual errors. The short chapter on the physics of radiation is quite inadequate for a book of this nature and contains no mention of the processes by which energy is transferred to matter.

These criticisms do not detract substantially from the book as a whole and the reviewers agree with the foreword in saying that the authors have made a useful practical contribution to a complex subject.

W. R. LOOSEMORE
W. G. SPARKE

Machine Translation. *Proceedings of a U.S. Symposium, Edited by H. P. Edmundson. Prentice Hall International, London*, 1961. 525 *pages*, £1 17*s.* 6*d.*

Behind this book stands an expenditure of $2 million per year (about £700,000) spent by the U.S. Government on research and development into automatic translation. In the U.S.A. and elsewhere, disciples of many arts contribute their share to progress in a new art: computer designers, system engineers, manufacturers of data processing equipment, linguists, mathematicians, librarians and psychologists. Further

in the background are chemists, physicists, economists, journalists and others who provide advice on terminology.

Control engineering is No. 68 in the synoptic chart for science and technology drawn up by the University of Washington, and several hundred special vocabularies appear to be necessary before the whole field of interest is covered.

This book illustrates both the usefulness of communication between man and man and the difficulties of communication between man and machine.

If only we knew how to instruct the machine to combine translated words, including the proper inflexions, declensions and other niceties of grammar, everything would be all right. At the moment we neither know enough of language nor do we have the machine for doing more than about half of the job. There is plenty of scope in this field for engineers and programmers who are interested in electronic switching, data processing and computers, and the informal tone of the discussions is perhaps more informative in this respect than the papers themselves.

Each session had four to six papers and of the 11 sessions three dealt with current research, three with grammar, one with semantics, one was devoted to dictionary and three to information processing, programming and to equipment used or under development.

Automatic character recognition, automatic indexing, automatic abstracting and information retrieval are certain to benefit from developments in machine translation.

L. A. STEINER

The Mathematical Theory of Linear Systems. *By B. M. Brown, M.A. Chapman & Hall, September,* 1961. 217 *pages,* 50*s.*

This book presents in a clear, logical and concise manner the essential mathematical principles concerned with the behaviour of linear systems. The presentation of these principles is rigorous without being pedantic.

The reader is given an interesting and valuable guided tour of the basic mathematics required for the study of physical engineering systems and the student with little preliminary knowledge should not find the tour too arduous.

The first chapters are devoted to the use of the " D " operator in the solution of linear differential equations, and the general theory of the book is based on the properties of these operators.

Following chapters clearly describe signal behaviour in the time and frequency domains, relationships between Fourier and Laplace transforms, step and impulse functions and their use in analysing arbitrary functions. Emphasis is placed on the use of the bilateral Laplace transform which will automatically account for the presence of steps or impulses with the initial switching of a linear system.

The extensive use of the " D " operator is to be supported in such a basic text, since this will give the student an appreciation of the natural behaviour of systems and leads to a better understanding of the more sophisticated operational methods.

The various methods available for assessing the stability of linear systems are clearly explained. These include use of pole-zero patterns, Routh and Nyquist criteria, gain and phase plots, and a cursory treatment of root locus methods.

Two chapters are devoted to the application of statistics in system analysis and optimisation. These give a simple but useful introduction to these important topics, and should be followed without difficulty by the average student. The timely introduction of optimisation in a linear system is demonstrated by the optimisation of filter parameters, and of a servo with constraints using Lagrange multipliers.

The final chapters are concerned with difference operators as used for systems with intermittent operation, Z-transforms, sampling systems and function generating from a sampling sequence.

Useful appendices are included containing information on complex numbers, partial fractions, statistics, matrices, etc.

Most of the mathematics of this book should be introduced to all advanced engineering students taking HNC, Dip.Tech. and Degree courses. Much time and effort is devoted by student and teacher to the study of certain branches of mathematics which serves no useful purpose. This mathematics will enable the student to study the problems of physical systems. Engineers, post-graduate students and research workers concerned with the many aspects of engineering systems will also derive benefit from this book. The student might find some of the later sections difficult to follow but by intelligent selection he will acquire useful knowledge.

Minor criticisms might be made of the lack of practical examples for illustrating some of the more obscure fundamentals, and the usefulness of the book would have been increased by additional emphasis on the solution of simultaneous linear differential equations by matrix methods. However, the book is thoroughly recommended as a mathematical introduction to a most interesting subject.

H. NICHOLSON

Corrected Optical Pyrometer Readings. *By D. E. Poland, J. W. Green, and J. L. Margrave. National Bureau of Standards Monograph* 30, *issued* 21*st April,* 1961, 74 *pp.* 55 *cents.*

This table enables optical pyrometer users to convert immediately the observed temperature to the true temperature, taking into consideration the effective emissivity of the observed material. Conversely, the table can be used to determine the effective emissivity if the true temperature is known, by comparing this temperature with the pyrometer reading.

The table gives observed temperatures from 1,000 to 3,000°K in increments of 50 degrees, and from 10,000 to 39,900°K in increments of 100 degrees. These true temperatures are tabulated for 49 emissivities ranging from 0·02 to 0·98 in increments of 0·02. These calculations were made on a 650 electronic computer using Planck's law, and the value $C_2 = 1{\cdot}438$ cm deg. for the radiation constant.

(Order from Superintendent of Documents, U.S. Government Printing Office, Washington, 25, D.C.)

Foreign remittances must be in U.S. exchange and should include an additional one-fourth of the publication price to cover mailing costs.

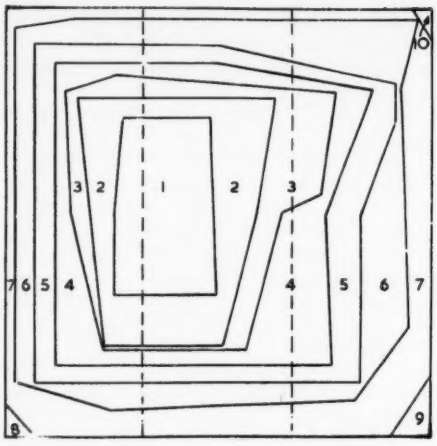


Fig. 1 (*a*).

Area	*Velocity range in ft/sec*		
1.	48·2	—	49·5
2.	47·0	—	48·2
3.	45·7	—	47·0
4.	42·8	—	45·7
5.	40·8	—	42·8
6.	36·6	—	40·8
7.	31·6	—	36·6
8.	30·0	—	31·6
9.	29·6	—	31·6
10.	27·9	—	31·6

Air velocity for duct ≏ 42·6 *ft/sec*

Fig. 1. *Velocity distribution in two rectangular ducts showing two-plane contraction and the resultant obstruction to the velocity distribution*

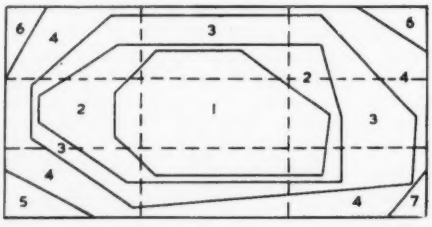


Fig. 1(*b*).

Area	*Velocity range in ft/sec*		
1.	69·7	—	71·1
2.	67·4	—	69·7
3.	61·4	—	67·4
4.	52·0	—	61·4
5.	48·8	—	52·0
6.	45·5	—	52·0
7.	41·5	—	52·0

Air velocity for duct 61·2 *ft/sec*

Rectangul

THE basic information which is at present available on Venturi tube design is the result of investigation and analysis by many workers over a great number of years.

Unfortunately nearly all past work, whether of a theoretical or practical nature, has been concerned with circular Venturi tubes installed concentrically in circular pipes. This is hardly surprising, since initially the great majority of Venturi tubes were used for the measurement of water flow through circular pipes; only comparatively recently have rectangular forms of Venturi tubes been used for the measurement of air and gases in rectangular ducts. (Note in this article we are using " rectangular " in a general sense to include square ducts.)

Two designs of circular Venturi have been established: that which follows the Herschell original design, and is now often called the conical or classical Venturi tube; and that developed in Germany which has the I.S.O. nozzle profile as the inlet section of the Venturi tube.

Whatever the design, the basic features which determine the performance of any Venturi tube and decide the characteristics of the discharge coefficient curve are the same, viz: (1) the positional and dimensional relationship of the throat pressure tapping relative to the angle of convergence of the approaching fluid stream, (2) the area ratio m, (3) the size of the pressure tapping, (4) the length of the parallel throat, (5) the position of the throat tapping in the throat, (6) the nature of the exit from the throat.

It is axiomatic that Reynolds number, pipe and internal profile roughness are overriding factors which form a framework within which the effect of these features must be considered separately or collectively. In spite of this formidable list analytical correlation of data has been attempted; the fact that it has not been skilfully done,is not to the point; the fact that it is possible without undue complexity is largely because the devices are circular.

The advantage of circularity is that concentricity can eliminate the positional influence of the Venturi tube relative to the upstream pipe. It thus becomes possible to investigate the interplay of the design features listed above against a background of stable predetermined conditions of test.

This state of affairs is more easily obtained in the case of circular pipes, because for a given installation for which the pipe diameter, pipe length and relative roughness are known, the distribution of velocities in the pipe will remain symmetrical with respect to the measuring device, and thus the position of elements of design, such as pressure hole position, only have to be considered in the axial sense, and no problem of radial position influence arises. This point should perhaps be reiterated by saying that provided the device is concentric with the pipe, then the radial position of elements of the device design, relative to the pipe,

Venturi Tube Design—Part I

By R. G. WEST*

cannot have a variable influence according to the segment of the pipe in which they may be positioned.

Circular and Rectangular Venturi Tube Designs

Here is the essential difference between circular and rectangular Venturi tube design. The influence of the duct shape cannot be ignored since the aspect ratio (breadth/depth) will decide the characteristic shape of the velocity distribution. The point is obvious, but to show the extent to which the characteristics of distribution may vary, the results of pitot traverses in two rectangular ducts are given in Fig. 1. As is apparent the profile shown in Fig. 1 (a) has a symmetry not unlike that found in a circular pipe which in fact can be considered to be a limiting condition. By comparison the distortion of distribution shown in Fig. 1 (b) is severe. Incidentally, the velocity distribution shown in Fig. 1 (a) was obtained in a straight duct 42 feet long. Since the velocity distribution of the air flow into this duct is regular, it appears that the slight asymmetry of the distribution shown in Fig. 1 (a) is evidently a characteristic of the flow through a long rectangular duct. There obviously is a tendency for the air stream to wander from one boundary to another, and thus it is similar to the characteristic flow of water in an open channel.

If we now consider a Venturi tube of any given area ratio, it will be apparent that the positional relationship of the essential design features to the velocity distribution must be carefully considered in both an axial and a radial sense. This point is illustrated in Figs. 1(a) and (b) which show by dotted lines the obstruction caused by a Venturi tube, m = 0·35 and thus the degree to which it and the momentum exchange will vary according to the value of the aspect ratio. It would therefore be unreasonable to expect that a standardised design applied without discrimination to the velocity profiles shown could possibly give the same characteristics of performance.

Discussion of cross-sectional shape of a rectangular Venturi tube is now useful; it is customary to use the form shown in Figs. 1 (a) and (b) because rectangular Venturi tubes are used to a great extent for the measurement of air in rectangular ducts, and it is more convenient and less expensive to fabricate a two-sided contraction as part of or within the duct rather than supply it as a separate unit. But even so the design of such a device is in the first instance concerned with the orientation of the contraction with respect to the aspect ratio of the duct. It can be seen from Figs. 1 (a) and (b) that the curvature of the fluid stream-lines will vary according to the relationship of the plane of contraction to the velocity profile. The low pressure, or throat component of the differential pressure created by a Venturi tube, is dependent upon this curvature and it is apparent that it will vary according to the degree of this contraction. It is for this reason that the axial position of the throat pressure tapping becomes of paramount importance.

For the same reasons the radial position of the pressure tappings relative to the upstream aspect ratio and velocity distribution cannot, as in the circular case, be ignored. Thus, although the area ratio of the contractions shown in Figs. 1 (a) and (b) are the same, the static pressure at tapping A1 of Fig. 1 (a) would be different from that of tapping A2 of Fig. 1 (b); the pressure at tapping A3, Fig. 1 (a), different from that at A4, Fig. 1 (b); and that at A4 different from those at A5 and A6. Following the same reasoning, tapping hole size may be expected to have a greater influence at tapping A1 than at tapping A4.

Influence of the Corners in Rectangular Ducts

Since this discussion has stressed that there is an additional importance of velocity distribution in the case of rectangular devices (similar remarks could be made about rectangular orifices) it follows that changes in the roughness of the internal surfaces of both duct and Venturi tubes will have probably more effect than for circular devices. It is, for example, interesting to consider the influence of roughness in the corners of the duct. In the case of a circular pipe of diameter D and

*Head of the Fluid Dynamics Laboratory, Electroflo Meters Co., Ltd.

length l, the wall shear stress is

$$\tau = \frac{\pi r^2 (P_1 - P_2)}{2\pi r l} \qquad \text{where } r = D/2$$

and is, for a pipe length of known cross-section, uniform over the whole perimeter. It will be obvious that there is non-uniformity of shear stress around the perimeter of the rectangular duct. Instead there will be a stress gradient away from the corner wherein, incidentally, the stress will be relatively high.

For it is apparent that apart from the corners, the shear stress will be related to the ratios k/B and k/D, or alternatively to $\frac{k}{2(B + D)}$. Whereas in the proximity of the corner, the roughness height effect on shear stress will be nearer to $\frac{k}{(xB + yD)^n}$, $x, y \leq 1$.

This means that the normal expression for shear stress:

$$\tau = \frac{(P_1 - P_2)\,BD}{2(B + D)l} = \phi\,(K/B, K/D)$$

is changed to:

$$\tau = \frac{(P_1 - P_2)}{(xB + yD)l} \frac{xByD}{} = \phi\left(K/xB, K/yd, \frac{2K}{(xB + yD)}\right)$$

Therefore any change in roughness height can be expected to cause more than the usual significant changes to the velocity distribution and thus to the coefficient of rectangular Venturi tubes. This is particularly true since although the change of roughness height may be uniform, the change of shear stress in the throat may be almost unrelated to that in the upstream duct. These conclusions lead naturally to the realisation that the so-called scale effect will be much more drastic for rectangular measuring devices.

Scope of Tests

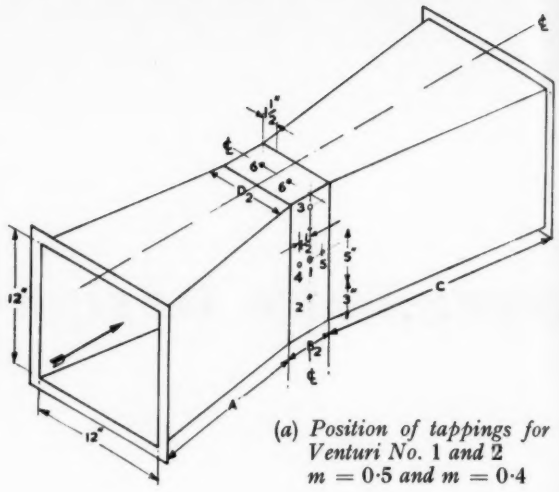
In view of the number of variables involved, the first stage of the investigation was restricted to an examination of the characteristics of four rectangular Venturi tubes. Primarily it is usual to assess the discharge coefficient and irrecoverable pressure loss characteristics. In the present case it was necessary to do so while at the same time taking account of the possible variation in coefficient values due not only to Reynolds number effect, but also to the size and axial and radial position of the throat tappings.

Therefore, differential pressures using the various throat tappings were taken simultaneously, together with pressure loss data obtained differentially between tappings one duct width upstream, and 7, 12 and 14 duct widths downstream of the test Venturi tube.

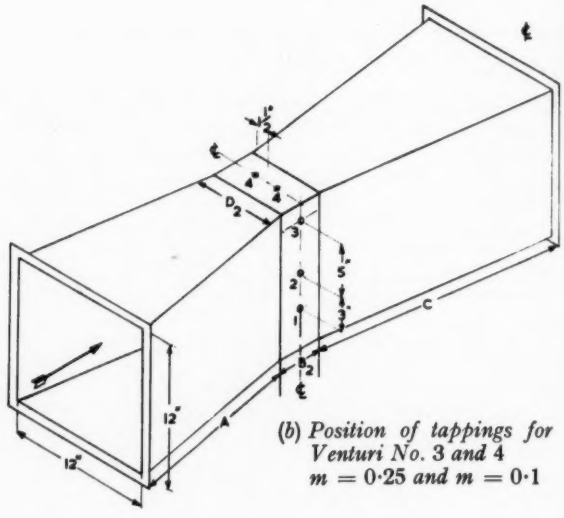
To test roughness influence the same procedure as was described in the previous series of articles was adopted, in which the original roughness condition of the upstream duct was retained while changes were made stage by stage to the roughness of the Venturi tube profile.

For each change a complete series of coefficient tests using all throat tappings were made. By reversing the stage-by-stage process and by repeating the tests, it was possible to isolate the effect of roughening any particular section of the Venturi tube.

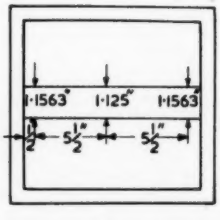
As a necessary preliminary to the main bulk of work complete pitot traverses of the test duct were made in order to obtain the velocity distribution. At the same time the pressure gradient along the duct was obtained from which friction coefficient data were calculated.



(a) *Position of tappings for Venturi No.* 1 *and* 2 *m* = 0·5 *and m* = 0·4



(b) *Position of tappings for Venturi No.* 3 *and* 4 *m* = 0·25 *and m* = 0·1



(c) *Throat width data for Venturi No.* 4

Fig. 2. *Venturi tube design*
Viewing from upstream, holes on left of centre line 5/16 *in. diameter, holes on right of centre line* 1/16 *in. diameter. Position of upstream pressure tapping* 6 *in. from flange on horizontal centre line.*

Details of the Test Duct and Test Venturi Tubes

The 12 × 12 in. duct test section was 42 feet long, and was made of mild steel. Construction of the duct was arranged so that each internal corner was perfectly square. The internal surfaces were treated to avoid rusting and before each set of tests a check was made to see that the condition of these surfaces was unchanged.

The four test Venturi tubes had area ratios m = 0·1, 0·253, 0·4 and 0·5. These were also made of mild steel and were constructed so that the corners were perfectly square and the geometry of each device symmetrical in all respects. In spite of these precautions it should be noted that one Venturi tube had a throat in which there was a slight dimensional disparity in width from top to bottom (see Fig. 2 (c)). The geometry of these Venturi tubes is shown in Fig. 2 (a, b, and c) and the results of dimensional checks after manufacture are summarised in the following table:

Dimensions of Venturi Tubes

Venturi Tube No.	m	A (in.)	B_2 (in.)	C (in.)	D_2 (in.)
1	0·5	$5\frac{1}{8}$	6	29	6
2	0·4	$6\frac{3}{4}$	4·8	$28\frac{9}{16}$	4·813
3	0·25	$7\frac{3}{4}$	3	$29\frac{1}{4}$	3·000
4	0·1	$9\frac{1}{2}$	1·25	29	See Fig. 2(c)

The disposition of the throat pressure tappings is also shown on Fig. 2 (a) and (b). Care was taken to see that all internal pressure hole mouths were flush and free from burrs; and it was particularly noted that all pressure hole mouths were situated within plane, truly flat surfaces. It can be commented here that the choice of this internal profile was purely arbitrary and it was realised that the test results might very well indicate that some detail of the profile could be changed with advantage.

Discussion of Test Results

The cross-sectional velocity distribution, in the 12 × 12 in. duct normal to the direction of flow obtained from the pitot traverses, is as shown in Fig. 1(a). The same information is also shown in Fig. 3 in the form of horizontal and vertical strata co-planar with the horizontal and vertical duct axes respectively. There is no logical explanation either for the small irregularities which appear in these curves near the duct boundaries, or for the general asymmetry of distribution. This latter condition is similar to the asymmetrical condition often found in open water channels of considerable length, and it appears to be due to the fact that the fluid stream meanders along the channel or duct. It is almost impossible to say that this phenomenon occurs only in square or rectangular ducts or channels but, so far as the writer knows, it is not often observed in closed circular conduits.

The characteristics of velocity distribution in circular and rectangular ducts of varying aspect ratio will form

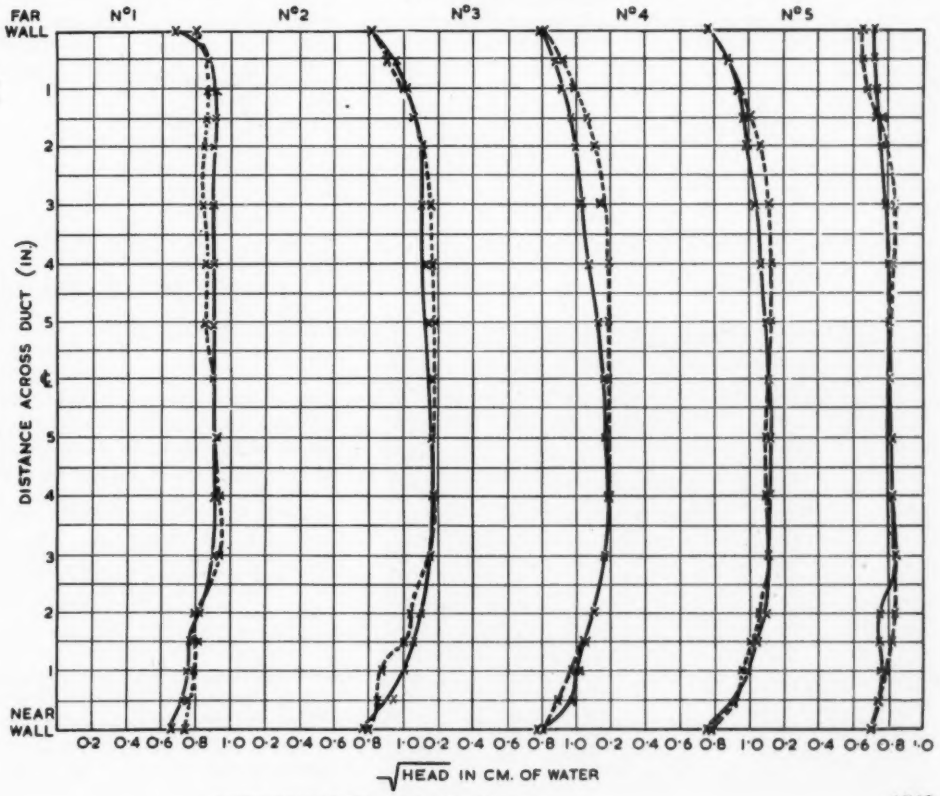


Fig. 3. Velocity distribution in a 12 in. square duct. Horizontal traverse (continuous lines) Vertical traverse (broken lines)

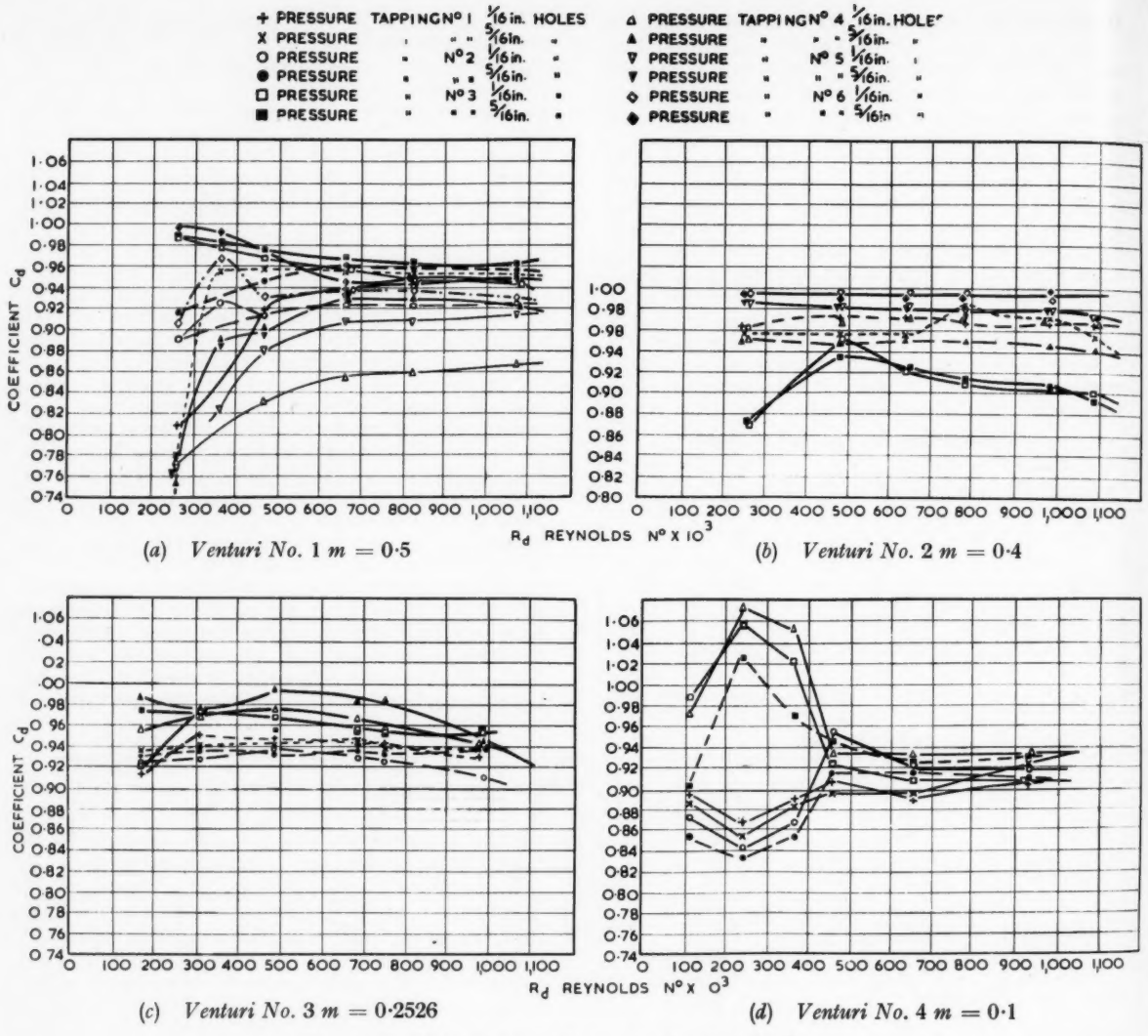

+ PRESSURE TAPPING N° 1 1/16 in. HOLES
X PRESSURE " " " 5/16 in. "
O PRESSURE " N° 2 1/16 in. "
● PRESSURE " " " 5/16 in. "
□ PRESSURE " N° 3 1/16 in. "
■ PRESSURE " " " 5/16 in. "
△ PRESSURE TAPPING N° 4 1/16 in. HOLES
▲ PRESSURE " " " 5/16 in. "
▽ PRESSURE " N° 5 1/16 in. "
▼ PRESSURE " " " 5/16 in. "
◇ PRESSURE " N° 6 1/16 in. "
◆ PRESSURE " " " 5/16 in. "
COEFFICIENT C_d
R_d REYNOLDS N° X 10^3
(a) Venturi No. 1 m = 0·5
(b) Venturi No. 2 m = 0·4
(c) Venturi No. 3 m = 0·2526
(d) Venturi No. 4 m = 0·1

Fig. 4. Coefficient tests on the rectangular Venturi tubes

the subject of a separate analysis which will eventually be the subject of another article. As far as the present investigation is concerned, attention is drawn to one point of interest. It is common practice to assume that the mean velocity strata is located at a distance of 0·7 × the pipe radius from the centre-line of the pipe in the case of a circular closed conduit. It is therefore surprising to find that the position of mean velocity in this square duct is located on a square whose boundaries are at a distance of 0·25 of the duct width from the duct wall. In terms of area division, therefore, the positions of mean velocity strata are identical in spite of the fact that the shape of the strata are quite different.

A further point is that there does not appear to be any shape effect in the determination of the friction coefficient λ since in this case the value of 0·012 obtained by test coincides with that of a 12 in. diameter circular pipe previously tested, and which appears by visual and impression techniques to have an identical surface to the 12 in. square duct under discussion.

The results of the coefficient tests on the Venturi tubes in the original smooth condition are shown on Figs. 4 (a, b, c and d). The presentation—against Reynolds number—is conventional, but requires comment here as the Venturi tubes are rectangular. In its basic form, Reynolds number is $\frac{V \times L}{\eta}$.

Where V is a velocity, L a representative length and η is the kinetic viscosity of the fluid.

Due to the extensive use of this group in connection with flow measurement in closed circular conduits, it is customary to identify L with the pipe diameter D or

throat diameter d. Consequently in order that these test results can be compared easily with the coefficient data applicable to standard circular Venturi tubes, the values of Reynolds number have been calculated using a value of D having an area which is equivalent to that of the square duct. Such a procedure is permissible if, as in this case, the friction losses per foot of pipe or duct are identical and the aspect ratio is near to unity so that the velocity distribution and the value of the ratio V_{mean}/V_{centre} are not too dissimilar to those in a circular pipe.

Nevertheless, this form of Reynolds number is unsatisfactory, since the essential nature of the duct and Venturi tube, i.e., rectangularity, is by-passed. Even the replacement of the term L by the hydraulic mean radius as is sometimes done for open channel hydraulics is of little value since it cannot count for the importance of aspect ratio and the physical size and shape of the duct. There is a pertinent discussion of these points by Leliavsky[1]. It is unnecessary to repeat Leliavsky's remarks here, except to say after reviewing certain work of Saph and Schoder, Von Mises, Caldwell and Shiller, he draws attention to the fact that the hydraulic mean radius can only be of use hydraulically and can only be independent of channel profile provided that the shear of the boundary is proportional to the square of the velocity. He is emphatic that Caldwell's contention that the hydraulic radius m must be replaced by

$$\frac{m}{1-0{\cdot}38\,e/m}$$ where e is eccentricity of core

is probably true. Caldwell had made experiments in which a circular pipe had been provided with inner cores of circular, square and hexagonal shape concentrically and eccentrically placed within the pipe bore. By such means the hydraulic mean radius was held constant but the velocities and discharges were found to be dependent upon the eccentricity. Thus the theory that velocities and discharges depend on hydraulic mean radius and not on eccentricity was disproved. It is therefore reasonable to say that hydraulic mean radius is not entirely a satisfactory parameter by which to judge hydraulic efficiency.

Leliavsky concludes, " There are still more reasons for believing that the estimate of the hydraulic efficiency of canal profile may possibly be derived in future from a more sound basis than the hydraulic radius. Here again there is a wide field for further experiment ".†

It is because of the uncertainties associated with shape and roughness that it becomes unwise to use the hydraulic mean radius form of Reynolds number, i.e. $\frac{V\,m}{\eta}$, where m is hydraulic mean radius. In any case, as we have already suggested, corner roughness influence tends to upset the hydraulic mean radius concept as well.

Trends Revealed by Coefficient Curves

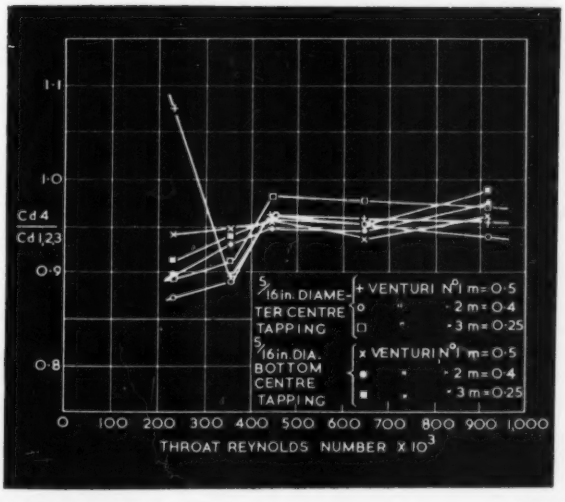
It is unnecessary in this first article to discuss a detailed analysis of this test data; such a discussion is best undertaken as part of the review of the completed test programme. Instead it must be sufficient at this stage to comment on various trends revealed by the curves. To begin with, coefficient constancy is one of the main features that are discussed in connection with Venturi tube performance. In this respect these Venturi tubes are not particularly satisfactory. It is of course possible to draw a constancy line for each area ratio on the basis of faired mean. But it is apparent that such a procedure could hardly be described as accurate and in fact ignores the essential non-linearity of the data.

It appears that, with few exceptions, size of throat pressure hole has little influence on constancy of coefficients. In fact it appears that pressure hole diameter variation merely causes a quantitative displacement of the curve, while at the same time retaining its characteristic.

A more revealing feature of these curves is the departure from constancy which occurs at Reynolds numbers below 500,000. To illustrate this point it should be observed that there occurs diametrically opposite changes in coefficient characteristic below the constancy limit in the case of the Venturi tube with the smallest area ratio. For certain pressure tapping positions there is a tendency for the coefficient to rise in a manner very similar to that of the square-edged orifice. While for other pressure tapping positions the coefficient falls in a manner more consistent with normal Venturi tube coefficient data.

If now the curves for the other Venturi tubes are examined, it will be noticed that the degree to which these opposing characteristics occur reduce with increase in area ratio until, in the case of the Venturi tubes m = 0·5, there is a tendency for them to become mixed in a rather haphazard way. It follows that the actual trend in coefficient values associated with any particular tapping size and position will also vary with area ratio. This point is apparent if the central tapping, No. 2 of the tube m = 0·1, is compared with the central tapping No. 1 of the tube m = 0·5. Other similar comparisons will be apparent from inspection of the coefficient curves, Figs. 4 (a, b, c and d) and also Fig. 5. The overall conclusion which can be drawn from these tests is that the geometric proportions of

Fig. 5. Graph showing relation between throat Reynolds number and the ratio of data coefficients for a given tapping size


1·1
1·0
Cd 4 / Cd 1,23
0·9
0·8
5/16 in. DIAMETER CENTRE TAPPING
+ VENTURI N°1 m=0·5
○ " · 2 m=0·4
□ " · 3 m=0·25
5/16 in. DIA. BOTTOM CENTRE TAPPING
x VENTURI N°1 m=0·5
● " · 2 m=0·4
■ " · 3 m=0·25
0 100 200 300 400 500 600 700 800 900 1,000
THROAT REYNOLDS NUMBER X 10³

†Quoted with the permission of Chapman & Hall Ltd.

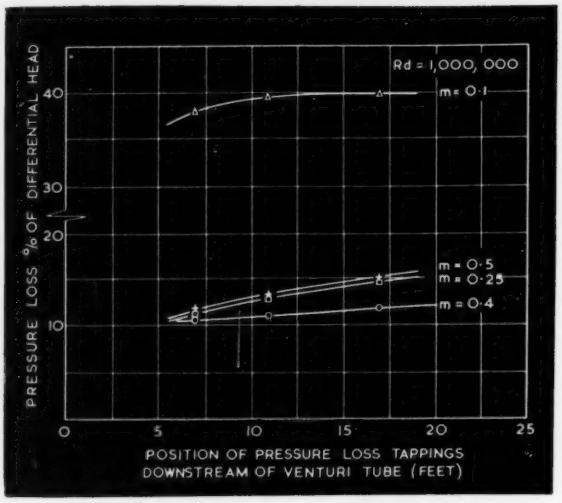


Fig. 6. *Pressure loss data*

the profile are unsatisfactory and that as a result the size and location of pressure tapping has an undue influence which gives a fundamentally unstable performance.

As in all cases of this sort it is always possible to find one particular area ratio for which the various adverse features of design offset each other, so that the resulting performance represents a compromise which may even have superficially a satisfactory characteristic. The Venturi tube m = 0·4 clearly falls into this category.

Some of the trends exhibited in these curves have a remarkable similarity to those noted by Witte (see *Instrument Practice*, **15** (6), June, 1961, p. 717, Fig. 6) with an investigation connected with circular classical Venturi tubes. It may be that the explanation offered by Witte concerning the radius of the corner forming the throat entry is valid for the present tests as well.

The results of the pressure loss tests are shown in Fig. 6. In general the irrecoverable losses due to Venturi tubes of this type are similar in magnitude to those caused by the circular classical Venturi tube, but it should be noted that the mechanism of recovery is less efficient and results in a steadily increasing loss to a point at least 20 duct widths downstream of the device. Calculation shows that the increase is due more to the inefficient mechanism of recovery than to friction drop in the duct itself. One other point of interest is that the high irrecoverable loss, caused by the m = 0·1 Venturi tube, confirms the coefficient trends in that it appears to behave more as an orifice than as a Venturi tube.

(To be continued)

References

1. Serge Leliavsky—Irrigation and Hydraulic Design, Vol. 1, General Principles of Hydraulic Design—London, Chapman & Hall Limited—1955. Pp. 371 et seq.

CORRECTION

In the article by Mr. West which appeared in the November issue of *Instrument Practice*, the captions to Figs. P.2 (a) and P.2 (b) on page 1396 should be interchanged.

Rocket Propulsion Symposium

The Proceedings of the Rocket Propulsion Symposium, held at Cranfield, 6th-7th January, 1961, have been published by Plenum Press, New York, for the British Interplanetary Society under the title *Rocket Propulsion Technology, Volume* 1. This conference was sponsored by the College of Aeronautics, The British Interplanetary Society, and The Royal Aeronautical Society, and contains all the papers read, as well as the formal discussions held.

Reliability and controllability in rocket engines are the chief topics dealt with in this significant volume. The six papers on controllability describe recent work on dual thrust and thrust axis control with solid propellant rocket motors, problems met in starting and stopping liquid propellant engines, and special difficulties arising with large engines using liquid oxygen. The " Spectre " variable thrust engine and also the control problems associated with the " Black Knight " high-altitude research vehicle and its propulsion system are described.

Rocket engine reliability is discussed in a group of papers under the following headings: the measurement and interpretation of reliability, aspects of design and development philosophies, the solid propellant motor, charge inspection, and metallurgical aspects of high strength motor cases.

In addition, several valuable papers on other areas of rocket propulsion are presented—many of them describing new experimental and test techniques such as instrumentation techniques, pump efficiency measurement, solid propellant internal ballistics, packaged liquid propellants, and hydrogen as a propellant.

Vulcanised Fibre Sheet for Electrical Purposes (B.S. 216 : 1961)

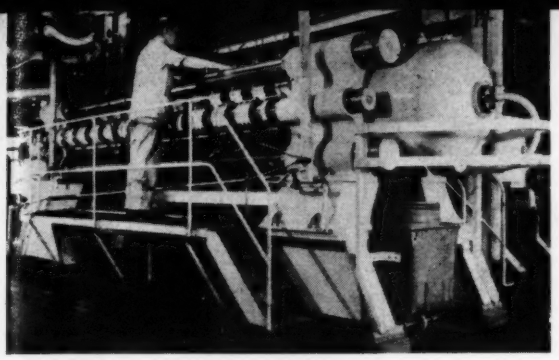
The British Standards Institution has published a revision of the 1936 edition of B.S. 216 covering two grades of vulcanised fibre sheet from $\frac{1}{16}$ inch to 1 inch in thickness for use in electrical equipment.

The original edition of this standard covered only one grade of sheet, which was of natural colour. The new edition now includes a second grade, having slightly lower properties. Either grade can be obtained in other colours, although natural colour is assumed unless otherwise stated.

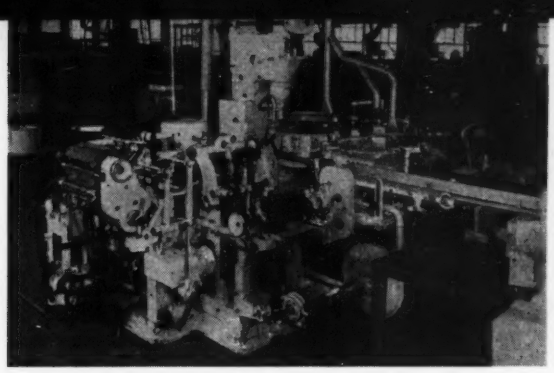
The test for water absorption has been omitted from the new edition, but a warning is given that the fibre should be used under dry conditions.

The methods of test have been revised to bring them into agreement so far as possible with the methods of test for other insulating materials.

Copies of this Standard may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1, price 6s. each, postage will be charged extra to non-subscribers).



View of the cocoa press



The cocoa packing machine

INSTRUMENTATION IN CHOCOLATE MANUFACTURE

Part 4. The Preparation of Chocolate

By R. D. HOSKIN
A.M.I.Mech.E., A.M.I.E.E., A.M.Inst.F.*

THE complete transfer of the business from the multitude of buildings centred around the Union Street premises to the centralised site in the heart of the country at Somerdale was completed in 1934, and up to this time chocolate manufacture had relied on batch processes and relatively expensive handling of raw materials.

Since the introduction of modern production methods, the output of chocolate has increased enormously, and the control of quality with this increased output has been rigidly maintained. This better productivity has been achieved by applying modern techniques to the problems of handling, mixing, and preparing the various ingredients, and this article sets out some of the methods used.

Preparation of the Cocoa Bean

By far the greatest tonnage of cocoa bean is obtained from the western part of Africa. The beans are cleaned and sorted to remove foreign bodies of all kinds, and also graded into sizes to secure uniformity of roasting. The latter process is carried out in indirectly heated roasting ovens, in which the beans are heated to a temperature of between 260°F and 280°F, and results in the development of the aroma, partially converting the starch into dextrin, and eliminating the bitter constituents. The beans also dry, and their shells become crisp. Finally, the beans are gently crushed and winnowed, the husks being removed, and the final product is then in the form of irregular pieces of bean known as cocoa-nib.

The process control involved in this part of the preparation is mainly in the roasting, gas ovens being used with thermostatically controlled oven temperature and flame failure devices. Additional care has also to be taken in the removal of the fumes produced during roasting, as these contain acetic acid, causing serious corrosion to ductwork. It is usual to employ stainless steel ducting in these applications. The conveyance of the bean through the various processes is by means of conveyors which are sequence controlled.

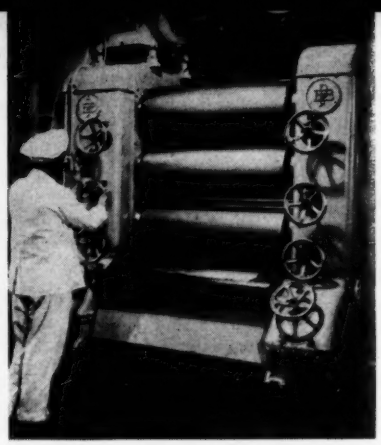
Following the preparation of the cocoa bean, it has to be further treated before it can be combined with other ingredients to form chocolate. The bean is finally ground in high speed grinders to form a semi-liquid substance known as " Mass ". This can then be pumped into storage containers, which are jacketed, for use as required.

" Mass " is one of the basic ingredients for both cocoa and chocolate, and although it would on its own produce a drink, it would be far too rich for most palates, and so a proportion of cocoa butter is now extracted by pressure, and this is used as another ingredient in the manufacture of chocolate.

The timing of the cocoa presses is controlled electrically, depending on the percentage of fat that is required in the cocoa remaining. The cocoa that remains after pressing is quite solid and as hard as rock—it is removed by conveyors to " Cake " breakers, and thence to mills, where it is ground very finely to pass through a sieve with a mesh of approximately 13,000 holes to the square inch. For the very best quality powder a considerably finer mesh is used. Fig. 1 shows a cocoa press of the type used with automatic cocoa production lines and Fig. 2 will give an idea of the complex

*Power Services Engineer, J. S. Fry & Sons Ltd., Bristol.

machinery used in the final weighing and packing of cocoa. The machine shown forms the outer container, lines this container with polythene, fills it with cocoa powder to the exact weight required, and rejects it if the weight is incorrect, and finally seals the top for packing into cartons.



The chocolate refiner

Chocolate Production

The method used for the production of chocolate will vary according to the type required, i.e. plain or milk, but the technique involved is basically similar. In the case of milk chocolate, sugar, milk and " Mass " form the basis of the final chocolate, the majority of the moisture in the milk, sugar and " Mass " solution having been removed in a vacuum plant. Additional cocoa butter is also added at this stage, and is thoroughly mixed to a paste in a paddle mixer or a melangeur. The correct proportion of ingredients is essential if consistent quality is to be maintained, and in the case of large scale production, continuous proportional feeding of the ingredients is usual. Because of the high cost of cocoa butter extreme accuracy is required, and it is for this reason that automatic metering of all the ingredients is to be recommended. This control is generally interconnected, with sequence controlled conveyor bands feeding the mix into the refiners. Refiners are large steel rolls through which the chocolate passes in the form of a thin film adhering to each roller. The adjacent roller is allowed to rotate at a different speed to its partner, and this results in a crushing and tearing action which reduces the crystal size to controllable limits, and improves the " Tasting " qualities. The photograph of a typical refiner installation is shown in Fig. 3, and this shows clearly the disposition of the steel rollers.

To provide the finest eating chocolate it is necessary to give it further treatment known as " conching ". This process improves the colour and flavour of the chocolate mass as conching develops, and at the same time the solid particles are still further reduced in size to give an increased palate solubility. The conches are water jacketed to provide controlled temperature during the whole of the conching process. The water temperature is maintained by pumps through temperature controlled calorifiers, and it is essential that the water temperature should be kept at a steady value which will be different for the two types of chocolate; dark chocolate being conched at a much higher temperature than milk chocolate. The conching process may take as long as 100 hours, depending on the degree of fineness achieved, and it is appropriate, therefore, to consider ways in which the control of fineness is maintained. The majority of methods in use at the present time all employ the principle of microscopy, samples of the chocolate under test being prepared in the form of slides, the image usually being projected on to a screen when the average particle size can be measured. It is usual for the particle size to be measured in microns. The finest chocolate is that with average particle size of between 15 and 25 microns. Experiments have been made to provide continued sampling and testing of chocolate production, using a sampling and scanning device, but so far results have not produced an economical method.

Before the material can be sold as a bar of chocolate, or alternatively used as a covering for a confectionery centre, it has to be first moulded in the liquid state, and then solidified, usually by refrigeration of some sort.

Chocolate when poured in the liquid state contains fluid cocoa butter, which will separate from the mass when cooled; this will result in white patches known as " Bloom ". It is therefore necessary to maintain the liquid chocolate in tempering machines, which provide continuous stirring of the chocolate, and even granulation of the fat. Control of temperature in the various stages of the machine is by hot water, and each section has its own independent controller. After leaving the tempering machine, the chocolate is pumped through jacketed pipes to an enrobing machine, or a depositor. Finally, the chocolate is conveyed into a cooling tunnel, and eventually reaches the packing end as the familiar product—ready for wrapping. Even at this stage care is necessary since if the unit to be wrapped has been cooled below the dewpoint of the packing room, condensation will form on the unit, producing unsatisfactory work. It is for this reason that increasing importance is being placed on careful control of packing room temperatures and humidity, and full air-conditioning of these areas is often necessary if outputs are to be maintained throughout the year.

More and more emphasis is being placed on conditioning of packing areas, and this has a beneficial effect in respect of labour control, as well as in production standardisation.

Summary

It will be appreciated that these articles have only attempted to outline briefly the main stages in the high grade chocolate production process, describing the ways in which control and instrumentation has helped to achieve constant quality, with ever-increasing output. It should be realised that the processes described in earlier articles are all supplementary to the main business of chocolate manufacture, and it is hoped that these articles will have given the reader an insight into the instrumentation and control in chocolate manufacture.

Acknowledgements

Finally, the author would like to express his thanks to all those who have assisted in the preparation of these articles, and especially to J. S. Fry & Sons Ltd. for permission to publish photographs of plant and equipment installed in their factory at Somerdale.

(*Concluded*)

Maintenance of Instruments

The Editor invites correspondence on this very provocative subject

AT the first National Maintenance Conference and Exhibition, one of the subjects of discussion was "Maintenance of Instruments". The chairman of the discussion was Mr. R. J. Redding, chief technical engineer, Automatic Control Engineering Ltd.

The discussion was attended almost entirely by instrument users and some very interesting points were raised.

In his opening remarks Mr. Redding gave a brief outline of what instrument maintenance can involve. In the case of some equipment frequent maintenance could very well cause more trouble than leaving the equipment alone. Again, incorrect testing could result in overload of the equipment being tested. This can be obviated by built-in test equipment in the instrument.

One technique of preventive maintenance is that of marginal testing, and by logging results one can predict when the instrument will fail. To-day the tendency is towards plug-in units and when a fault occurs the faulty unit is just replaced by a new one. Here, Mr. Redding mentioned a rather costly disadvantage and that was that units with nothing wrong with them may be thrown away.

In the case of holding spares, Mr. Redding warned that the shelf-life and the working life of some equipment and components was comparable. Another point Mr. Redding made was that users should not modify instruments themselves but should leave this to the manufacturer.

On the basis of questions he had received, Mr. Redding suggested that these should form separate subjects for discussion.

Instrument Maintenance and Plant Maintenance—Together or Separate?

The general opinion on this subject was that for the larger organisation it was essential for instrument maintenance to be handled separately. The complexity of instrumentation is continuously increasing, particularly in the field of analytical instrumentation and specially trained men are needed to maintain these instruments. These specially trained men, which in the case of I.C.I. may have HNC or degrees, can break down a complex job into a series of simple tasks so that tradesmen can carry out the actual repairs.

In some areas, for example Scotland, there were no adequate educational courses available for instrument technicians, and British Hydrocarbon Chemicals Ltd. found that of their qualified instrument engineers half had been trained by the Services and these formed the background of the electronic section. As a contrast to this, the National Coal Board found that the Newport Technical College of Wales had a good course for instrument engineers.

Is the Instrument Industry's Service to the User Sufficient?

The first points raised concerned spares, their cost and their delivery. The experience of the C.E.G.B. at West Thurrock Power Station was that in the case of spares for transistors, if one didn't deal direct with the manufacturer one had to pay three or four times more than the manufacturer's price.

Some very harsh comments were made on the question of delivery dates of spares. New instruments could be obtained quite quickly but one often had to wait up to three months for spares. One speaker wondered if the manufacturer perhaps thought the user should buy another new instrument and use parts from it as spares for the one he already had!

The instrument users could perform a valuable service to the manufacturer by feeding back to him information on how equipment is operating, its reliability, number of breakdowns. It was found, however, from experience that such information was unfortunately not well received by the manufacturer.

On the question of repairs, several users felt that the manufacturer sent along a trainee to repair equipment so that in effect the user was helping to pay for his training. The experience of the refinery maintenance engineer at the B.P. Refinery (Kent) Ltd. was that he had never been approached by instrument manufacturers offering to service instruments. His opinion was that few instruments are developed by the actual manufacturer. They were usually manufactured under licence and this was a great handicap to offering good service. On the "bread and butter" run of instruments, manufacturers had been found keen to help train staff to look after them, but in the case of special instruments the manufacturers say they can service them but in fact they can't.

On this whole question of service offered by the instrument manufacturer, the users found that the large manufacturers offered excellent service, but the small manufacturer didn't give his instruments sufficient field trials.

Electronic v. Pneumatic Instruments

The Mobiloil Co. a few years ago made comparative costs between pneumatic and electronic equipment and everything was found to be in favour of pneumatic systems. The electronic equipment to do the same tasks costs anything between 125% and 400% more. The speaker was not convinced that the trend towards electronics will necessarily take place and mentioned the "solid-state pneumatic" computer which the Russians have been developing.

A similar view in favour of pneumatics was expressed by the works instrument engineer of Imperial Smelting Corp. who thought that electronic control would come, but at the moment all their control is pneumatic. Pneumatic controllers designed 10 years ago were still working perfectly without replacement and he was not convinced of the advantages of electronics!

The instrument maintenance engineer at I.C.I. Alkali Div. was sorry to hear of the timidity of approach

to electronic equipment which seemed to be a little out-dated as the reliability, convenience and usefulness of electronics had been proved. This point of view was backed up by the Billingham Div. of I.C.I. who found that pneumatic equipment wears out faster than electronic equipment and also went out of date quicker.

On the question of obsolescence the chairman, Mr. Redding, said that with the rapid advances in the field it was reasonable for electronic equipment to go out of date in about five years. However, one could keep equipment going with new components and to avoid obsolescence one could specify components meeting Service Specifications which would give the same characteristic, though of course this would become expensive.

The real point in the argument of pneumatic v. electronic equipment is what is it being used for and what is required ?

Operation of Instrument Maintenance and Technical Training

Most instrument users agreed that the instrument artificer who has acquired knowledge sufficient to maintain instruments should be paid over and above the wage rates for craftsmen agreed by Trade Unions. Each user had various methods for implementing this which avoided antagonising the Unions. In some cases apprentices who gained their HNC then ceased to be craftsmen, in another the instrument technician who was teaching the craftsmen was paid half what the craftsman earned and therefore there was no trouble with the Union. This problem, however, would become more serious as instruments became more complex and more numerous.

All users agreed that training schemes were necessary to re-educate production people so that they would have more confidence in instruments.

The educational system at present is adequate for producing the top grade instrument man, who holds a degree or equivalent qualification but has no course available for training the middle grade man, the technician, and it is this type of man which is in great demand. It was agreed that what is wanted is a continuous and flexible educational programme.

COMPUTERS AID SATELLITE WEATHER FORECASTING

THE Tiros III weather satellite circuits the earth every 98 minutes at a height of 450 miles above the earth. During each orbit 32 pictures can be recorded and the pictures relayed when the satellite is near one of the two principal ground stations. The problem of relating the cloud pictures to their location over the earth is assisted by the preparation of perspective longitude and latitude grids using computing systems at the ground stations.

The computers are used for real-time processing of information transmitted directly from the satellite. The computers predict satellite attitude as well as determine position at the time of the picture-taking. From this information, the location of specific meteorological features in the pictures can be found. The computers are programmed to draw the overlay grids which are employed in picture interpretation. The prediction of satellite attitude is used for control purposes as this determines where the cameras are aimed and when pictures can be taken. Equipment used is a Bendix G-15 computer, two MTA-2 magnetic tape units, a PA-3 graph plotter and PR-2 high-speed photo-reader.

Before the map grids can be constructed it is necessary to determine where the satellite is located in space at any particular time and in what direction the camera is aimed. When the computer has calculated this the computer's plotter unit can then begin to draw the perspective latitude and longitude grid. The grids are drawn at 5° intervals, but can be spaced at any interval desired.

Additional information that is calculated by the computer and drawn on the grid includes:

1. Principal line—the only straight line in the perspective grid, it is always perpendicular to the horizon and passes through the principal point and the satellite point
2. The horizon line is plotted and an arrowhead inserted at a calculated latitude and longitude to point north
3. Fiducial direction—when combined with sun angle data of another form helps orient the picture
4. A set of three triangles identifying where the sun's rays are striking the earth for the present picture, previous picture and the next picture. This is a meteorological feature that aids in the identification of visible sun glint
5. Geography line appropriate to the latitude and longitude (optional).

In summary, for each grid within a sequence the programme calculates the satellite position and the orientation of the satellite relative to local co-ordinates. It then computes the general transformation from object space (earth, clouds, etc.) to the camera image space using the proper position and orientation of the satellite. The horizon image is calculated and plotted. A latitude-longitude point known to lie in the picture is calculated and the picture boundaries located. The programme then calculates the necessary array of latitude-longitude intersections, drawing the line as it proceeds.

For assistance in aligning the pictures with the grids, the computer also calculates and plots the sub-point (location of satellite over earth), principal point (picture centre point on earth), and the centre of the sun reflection which often can be observed from open water surfaces. In addition the programme stores this data so as to plot the path of principal points on each grid, a procedure which is useful in analysing the relationship between successive pictures.

SYSTEMS TESTING FOR THE VICKERS VC.10 AIRCRAFT

THE new Vickers VC.10 aircraft is due to fly next year and test rigs of the six major systems of the aircraft have been built, or are nearing completion. These are the flight control system test rig, the autopilot test rig, the hydraulic, electrical and fuel systems test rigs and the air conditioning test rig.

Air Conditioning

The ducting is installed together with a mock-up cabin section and flow distribution tests are being made to investigate and equalise the flow rates from the air nozzles along the fuselage length. The instrumentation used is the same as will be used for the flight test and the purpose of the rig is to prove the system and to establish satisfactory air distribution before installation in the aircraft.

Flight Control System

The flight control system test rig is designed to simulate flight conditions as closely as possible, and resistive loads are applied to control surfaces corresponding to those experienced in flight. To reproduce deflection effects the stiffness of the rig structure in the regions of the powered control actuators is made equivalent to that of the aircraft structure. All the components of the system, which is a full size replica of the aircraft powered flight control system, have the same relative positions in the rig as they will have in the aircraft. The rig will be used for continuous running simulated flights, crew training as a flight simulator, failure investigations by deliberately sabotaging parts of the system, and for solving production assembly problems.

Autopilot System

This test rig, together with the hydraulic test rig, has been built close to the flight control rig so that when required they can be connected for integrated systems trials. The trials undertaken on this rig will include using the yaw, pitch and roll control functions to operate a rudder power control unit to check theoretical work. All aspects of flight, including emergency cases, will be covered and also trials with auto-flare equipment.

The gyro sensing unit, normally attached rigidly to the airframe, is mounted on a three-axis table which simulates movements of the aircraft in flight when moved by remote control. The aircraft aerodynamic and inertia characteristics are reproduced by an analogue computer which controls movement of the three-axis table.

Hydraulic System

In its final form this test rig will include pumps, reservoirs, piping, cockpit controls and landing gear, flap and slat mechanisms. The rig will be used for functional, fatigue and fault investigation trials.

Electrical System

The electrical system of the VC.10 is basically the Westinghouse constant frequency system, developed for the VC.10. The main purpose of the test rig is to prove these developments, to check various failure cases, and to evolve flight engineers' fault procedures.

The generators are Westinghouse 40 kVA brushless alternators, driven through Sundstrand constant speed units from the aircraft engines. On the rig these units are driven by electric motors controlled to simulate engine characteristics of speed and acceleration. This rig has been in operation for fourteen months and is well advanced with its programme.

Fuel System

The rig is a full size replica of the VC.10 left and centre section wing, pivoted about one point to give pitch and roll attitudes. The dummy wing is built of steel and internally is an exact copy of the real wing. If a right wing is required, drum tanks of equivalent volume are used.

The rig has been in use for the past sixteen months for a variety of tests which have included: gauging tests at various tilt angles, measurements of refuelling and defuelling rates, flow rates to the engines, effects of over-fuelling when a shut-off valve fails to operate, trials of venting and water draining systems.

Structural Tests

A forward fuselage section has been built as a test specimen representative of the complete fuselage structure, and has been undergoing pressurisation trials in a water tank. The fatigue properties of the pressure applied on a simulated flight basis will be examined by continuous cycling in the stratosphere chamber.

A structural test frame for a complete aircraft is being constructed and will be in operation early next year. The specimen to be used will be the second airframe built, production of which is well advanced. Proof load tests are to be carried out before first flight of the VC.10. These will be followed by a series of fatigue tests which will be programmed to simulate a series of representative flights and gust loads. Effects of take off, landing, fuel loads, flaps and air brakes are included in the programmed flight cycle.

When sufficient data are available from these tests the specimen will be used to demonstrate the fail safe properties of the structure by deliberate severing of members and application of loads.

CALIBRATION OF OPTICAL PYROMETERS

OPTICAL pyrometers are instruments used to measure the brightness temperature of incandescent objects. They are also used to realise the International Practical Temperature Scale above 1063°C. The National Bureau of Standards, as part of its programme to ensure accurate and uniform measurements, calibrates optical pyrometers for science and industry. These calibrations are performed over the temperature range of 800—4,200°C; the uncertainty of the calibration varies from about 3 deg (at 1,063°C) to 40 deg (at 4,200°C). In addition, the Bureau calibrates tungsten strip lamps for use as sources of known brightness temperature over the range of 800—2,300°C.

In general, an optical pyrometer[1,2] consists of an optical system through which the object whose temperature is being measured is viewed, and a power supply which is used to apply a variable current to a thin tungsten filament within the optical system. The current is adjusted until the filament disappears in the background of the object being viewed, at which time either temperature, voltage, or current can be read from the current-controlling dial. A red filter is placed in front of the eyepiece to ensure that a limited range of wavelengths is being viewed. As the maximum brightness temperature attained with the tungsten filament is about 1,350°C, provision is made to place absorbing filters in the optical system (either in front of the foremost objective, or between the objective and the filament lamp) to permit measurement of higher temperatures.

NBS Pyrometer

The NBS pyrometer, against which other pyrometers are compared, was given a primary calibration. This was done by making a large number of observations (by several different observers) of a black body cavity surrounded by freezing gold, the temperature of which is defined as 1,063°C on the International Practical Temperature Scale. In addition to this one-point determination, the calibration was extended to higher and lower temperatures by viewing a tungsten strip lamp at different brightness temperatures, the temperatures being determined by matching the brightness of the lamp through rotating sectored discs of known transmissions with the black body (1,063°C). The pyrometer lamp current corresponding to the various temperatures was determined with a potentiometer. The same type circuit is used to measure the currents in the filaments of test pyrometers during calibration.

Calibration Procedure

Instruments submitted for calibration are compared with the NBS pyrometer while viewing a tungsten strip lamp which is used up to 2,400°C brightness temperature and, if higher temperatures are desired, zirconium and carbon arcs. The brightness temperature of the zirconium arc is about 2,800°C, and that of the positive crater of the carbon arc is about 3,530°C.

In setting up the pyrometers for a comparison calibration, the optic axes of the test and NBS pyrometer are made parallel. The source is mounted on a lathe bed, and is mechanically transported to alternate positions in front of the two pyrometers. The source is adjusted so that the image of its sighting area is coincident with the sighting area of the filament lamp in each pyrometer.

Before observations begin, the source is allowed to stabilise; this takes but a few minutes for the arcs, but an hour is allowed for the strip lamp to become stable. Then, in a darkened room, the source is positioned in front of the NBS pyrometer. Two observations are made, and then the source is transferred to its position in front of the test pyrometer. Four observations are made with the test pyrometer, and then two more observations are made with the standard. This series is repeated with a second observer. Measurements are made from both sides of disappearance: starting with the filament both brighter and darker than the source.

When a strip lamp is used as the source, the constancy of the lamp brightness is assured throughout the comparison by monitoring the lamp current. Also, when making a series of readings with a strip lamp, the lamp is brought to the highest temperature first, and then decreased, as this procedure results in the shortest stabilisation times between settings.

The results of the calibration are reported to the user on an NBS certificate. Usually, the scale reading of the test pyrometer corresponding to black body temperature is listed. However, temperature versus current or voltage may be reported if requested.

Strip Lamp Calibration

Lamps consisting of a strip of tungsten housed in a gas-filled envelope are calibrated by means of brightness temperature determinations made with the NBS pyrometer. The lamp and pyrometer are aligned as in pyrometer calibration and, after a warm-up period, the strip lamp current is determined at the same time as a pyrometer observation is made. Four observations are made by two observers at each point of the calibration. The lamp current versus brightness temperature (as determined with the NBS pyrometer) is reported to the user.

Photoelectric Pyrometer

A photo-electric pyrometer that uses a photomultiplier tube rather than the human eye to make brightness matches between sources of interest and the pyrometer lamp has been developed at NBS. After proper testing and calibration this device will be used in the calibration of pyrometers and strip lamps. It will eliminate the variability in these calibrations that is due to the lack of precision of the observer.

References

1 Theory and methods of optical pyrometry, H. J. Kostkowski and R. D. Lee, presented at the Fourth Temperature Symposium, Columbus, Ohio, March, 1961, and to appear in Vol. 3, Temperature—Its Measurement and Control in Science and Industry, Reinhold Pub. Co.

2 The NBS photoelectric pyrometer of 1961, by R. D. Lee, *ibid.*

SIMA Notes

SIMA Delegation in Italy

The SIMA delegation has now returned from Italy after a most interesting and, it is thought, useful tour. Members of the delegation were unanimous in their views that the visit had achieved all and more than it set out to do. In particular Mr. A. W. Jones, president of SIMA, said that no praise could be adequate for the assistance given by the Embassy and commercial staffs in London and Milan, and that a great deal of the success of the visit was due to the help given in arranging meetings and talks at the highest level.

A detailed report is being prepared and it is hoped that this will be available early in December.

SIMA 10th Convention

The 10th SIMA Convention, with the theme " Exports ", was held at Eastbourne on the 15th—18th November. Some seventy member firms were represented by over one hundred and fifty delegates. A very full programme was enjoyed by all who attended, and a great deal of interesting ground was covered to the benefit of all. The Convention ended with a most successful and enjoyable dinner-dance which was attended by the Mayor of Eastbourne and the guest of honour was The Rt. Hon. Dame Patricia Hornsby-Smith, D.B.E., M.P.

SIMA Visits

Mr. A. W. Jones and a small party from SIMA visited the Atomic Research Station at Harwell and were received by the director and senior members of the staff.

Informal discussions were held on matters of mutual interest, including design of instruments and the possibility of increased support for export sales and the necessity for closer liaison between the industry and the establishment. The party then went on a conducted tour of the establishment, visiting several different projects.

The president expressed his thanks for the invitation and for the time given up by the senior staff of the establishment in showing the party round.

Enquiry Service

The SIMA Enquiry Service is still expanding and latest figures for enquiries show that these are now running at the rate of 6,000 a year, which is some 42% better than our previously estimated figures; of these some 25·2% are enquiries from abroad, covering practically every country in the world.

Trade Statistics

The first stage of the analysis of the exports of the industry and of the U.K. share of markets in Western Europe and the U.S.A. has now been completed. Breakdown figures by products under certain headings have also been completed and they will be useful for a variety of purposes, particularly in connection with the Common Market.

These figures will now be kept up to date on a yearly basis and will of course be available to members.

Exhibition Sub-Committee

In view of SIMA's increasing activity on the exhibition promotion side, a new sub-committee has been formed whose charter covers such matters as the evaluation of exhibitions and markets and the production of exhibition programmes for the Association. In addition they will deal with many enquiries concerning exhibitions and will be responsible for ensuring that SIMA's efforts are channelled into the most effective venues.

Northern Area Group Luncheon

The Northern Area Group held their annual luncheon at Manchester on the 4th December. The guest speaker was Dr. K. M. Sevosnick, Department of Economics, The University of Stockholm, who spoke on the effect of the Common Market on Britain's relations with the Outer Seven.

Apprenticeship Scheme

The following members submitted certificates for endorsement and this was duly completed at the last meeting of the Council.

R. & J. Beck Ltd.—one.
Taylor, Taylor & Hobson—two.

Calder Hall 5th Anniversary

SINCE the opening of Calder Hall five years ago, the world's first industrial scale nuclear power station, four Atomic Energy Authority's reactors at Calder Hall and the four similar reactors at Chapelcross, Scotland, have supplied to the National Grid 5,920 million kilowatt hours of electricity.

Operating experience gained during the first five years has been of major importance to the development of nuclear power, and extensive investigation has revealed no reason why the eight Calder Hall and Chapelcross reactors should not achieve their twenty years' design life.

Among the general conclusions to be drawn from the operating experience gained so far, are that heat and electrical output have considerably exceeded design expectations. Reliability in continuous operation and reduction of fuel-changing and maintenance shutdown periods have been such as to achieve load factors of over 85% although all fuel changing has to be carried out with the reactors shut down. This compares favourably with the best capability of the latest coal-fired stations. The Magnox-canned uranium Calder fuel elements have successfully withstood periods of irradiation in the reactors far longer than they were designed to achieve, without significant increase in fuel element failure rates. These results have been achieved despite extensive use of the reactors for experimental work in aid of the larger nuclear stations now commissioning or under construction.

Circle **346** for further information

NORMA
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No more cranking!

A Portable light weight insulation test set suitable for measuring the insulation resistance of all components installations, etc.
Cranking is obviated by the utilisation of a transistor converter; the power supply being two 4½ volt dry batteries.
The test voltage and range are selected by push buttons which facilitate quick and easy reading of the resistance value.

INSULATION TEST SET

TYPE 667

Range 0 to 10,000 megohms

4 TEST VOLTAGES with push button selection

100 V.
250 V.
500 V.
1000 V.

SIZE 8½" × 5" × 4½"
WT. 5 lbs.

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SURVEY OF NEW INSTRUMENTS

ELECTRICAL · ELECTRONIC · MECHANICAL · NUCLEONIC · PNEUMATIC

Five-figure Digital Voltmeter

DIGITAL voltmeters Type LM 1010, from Solartron, measure d.c. voltages from 20 μV to 1·5999 kV, with polarity discrimination, and provides simultaneous print-out signals within 20 milliseconds.

Voltages are measured with an accuracy of ± 0·05% of reading or ± one bit, whichever is the greater. On the most sensitive of the five ranges the one bit resolution is 20 μV. Two other additional ranges have scaling suitable for iron/constantan and Chromel/Alumel thermocouple inputs to give direct temperature readings. By switching to alternative two or five bit resolution it is possible to eliminate any jitter caused by small spurious signals. A switched filter network also gives approximately 20 dB attenuation of mains ripple that may be present on the input.

Input impedances of 1000 MΩ on the two most sensitive voltage ranges and the two thermocouple ranges enable the instrument to be used in capacitance transfer method of d.c. voltage measurement.

The LM 1010 can be switched for manual or auto operation.

The five-figure digital display is by optical projection with red or black backgrounds to indicate positive or negative inputs respectively. Decimal outputs at −12 volts d.c. are extended to a 75-way rear-mounted socket for driving an in-line printer or remote digital display. Overall dimensions are 10 × 18 × 16 in. (25·5 × 46 × 40·5 cm) and weight 50 lb (22·5 kg).

Circle **1** *for further details.*

Silicon Planar/epitaxial Switching Transistor

RCA's computer transistor line now includes two new silicon n-p-n transistors, RCA-2N1708 and 2N708 for military and industrial equipment. The 2N1708 silicon planar-epitaxial switching transistor is available in the TO-46 package, and has low collector saturation voltage at high collector current $-V_{CE}(sat) = 0{\cdot}22$ V max. at $I_C = 10$ mA; 0·35 V max. at $I_C = 50$ mA. It has low collector cut-off $I_{CBO} = 0{\cdot}025$ μA at $V_{CB} = 15$ V and short storage time of 25 μ sec max.

The 2N708 in the JEDEC TO-18 package is a planar type for very high speed switching applications. It has low collector cut-off current $I_{CBO} = 0{\cdot}025$ μA at $V_{CB} = 20$ volts.

Circle **2** *for further details.*

Oil Burner Sequence and Flame Failure Control

PHOTRONIC CONTROLS LTD.'s range of oil burner sequence and flame failure control units are designed to the latest British Standards Specification and are suitable for all types of oil burners.

The basic system is that of a synchronous motor and cam operating in conjunction with a photo-resistive photocell. No bi-metals or valves are employed in the circuit and this, coupled with the use of sealed plug-in relays, ensures long life with the absolute minimum of maintenance.

By the use of an adjustable cam system time periods can be provided to suit all requirements.

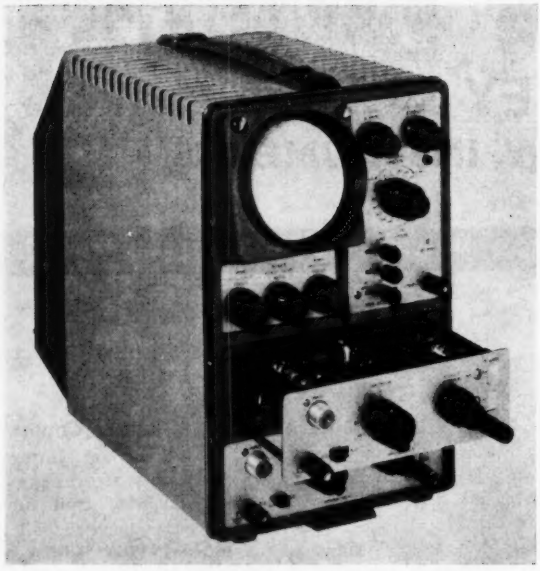
The equipment is designed to fail safe in the following circumstances:

1. By the use of a safe start relay system the unit will not start up if:
   (a) the photocell is seeing light at the start of cycle
   (b) the photocell leads or the photocell itself become short circuited
2. Should the relay coils go open circuit
3. If the flame is not established in the "flame establishment period"
4. In the event of electricity supply failure
5. In the event of abnormally low supply voltage
6. If the oil relay contacts become welded together
7. On flame failure at any time.

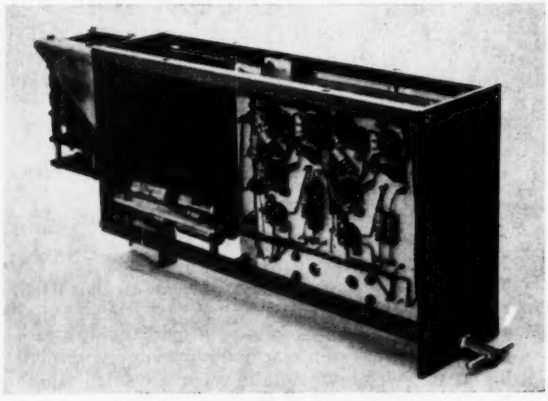
When used for heavy oil burner control, additional cams can be employed to operate solenoid valves, induced draught fans or for other operations. The same principle with associated relays will provide high/low control and fully modulating control in conjunction with the appropriate motors and thermostats. This sequencing unit can also provide the basis for a control panel incorporating motor and heater contactors all inter-wired and with time clock and switch fuse unit if required. Control systems and panels can be built to suit the requirements of any type of burner.

To satisfy the safety requirements when used with steam raising plants a low water cut-out system can be incorporated requiring a manual re-set once the equipment has closed down due to low water. This low water safeguard can also be supplied as a separate unit if required.

Circle **3** *for further details.*

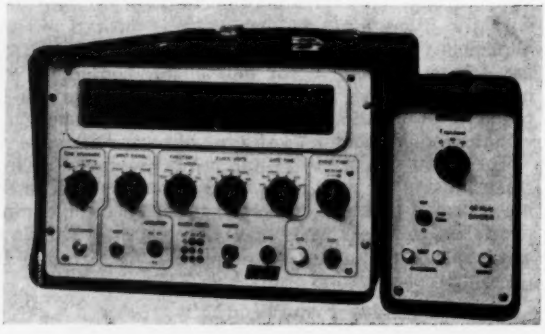


Telequipment Serviscope Model D.33



▲ *2 × 300 V stabilised power unit with side panel removed*

▼ *Racal divider unit*



Oscilloscopes

TELEQUIPMENT LTD. have added two models to their range of Serviscope oscilloscopes.

Of the two models S32 is a high performance development of model S31, which it replaces, whilst D33 features alternative plug-in amplifiers and is capable of tackling a wide range of applications.

Any of the basic range of amplifiers can be supplied or special units can be built to individual requirements. Of the basic range, " A " is a general purpose amplifier with a wide frequency response and the additional facility, when needed, of × 10 sensitivity over a limited bandwidth. " A " has many applications, especially in servo computer, T.V. and radar development and maintenance. With amplifier " A ", model D33 costs £112.

" B " is a differential amplifier unit giving high gain; maximum sensitivity is 1 mV/cm d.c., frequency response 200 kc/s. The unit adapts the D33 to work in the electro-mechanical field and to medical and biological applications.

" C ", an ultra high gain amplifier, has maximum sensitivity as high as 100 μV/cm a.c., frequency response 5 c/s to 150 kc/s—primarily for application in the electro-acoustical and magnetic recording fields.

A new feature of the D33 is a very high voltage (3,500) p.d.a. tube of advanced design. Accessories include a high impedance × 10 divider probe, camera attachment and extendible light hood.

A similar p.d.a. tube is incorporated in Model S32. Model S32 has a bandwidth increased to 7·5 Mc/s at 100 mV/cm and a high gain position providing 10 mV/cm, d.c.—to 200 kc/s. The S32, which will operate from a 110 or 200/250 V supply, costs £78.

Circle **4** *for further details.*

Stabilised Power Unit

A STABILISED power unit with two separate and independent 300 volt d.c. outputs, operating from a 200/240 a.c., 50 c/s, single-phase input, has been designed and is now being marketed by Experitron. The maximum current available from each output is 200 mA.

The output is stabilised to ±0·2% for nil to full load and, at the same time, the unit will cope with an input voltage fluctuation of up to ±5·0%. The maximum hum and ripple of the stabilised d.c. output is 15 mV. There is a pre-set voltage control at each output.

The unit has been designed so that five can be assembled in a standard 19 in. rack mounting. Each unit measures 6 × 3½ × 15½ in.

There are voltage and current monitoring sockets on the face of the unit and meters can be fitted as extras. The unit can also be supplied with a variable voltage swing of 200 to 300 volts at each output.

The price of the basic unit is £60 and delivery is six to eight weeks.

Circle **5** *for further details.*

Direct Frequency Measurement

THE SA. 512 40 Mc/s divider unit, developed by Racal Instruments, is a fully transistorised equipment utilising new circuit techniques and having the added advantage that no tuning is required. Normally supplied in a small bench mounting cabinet, the 40 Mc/s

divider is designed to be used with the Racal digital frequency meter Type SA. 505 from which it not only draws power supply requirements but upon which it gives direct in-line readout indication of the measured frequency. The 40 Mc/s divider may also be used with any other suitable frequency meter having standard decade time-base setting (0·01, 0·1, 1·0 and 10 second).

The SA. 512 comprises two cascaded transistorised current fed binary stages and the necessary shaping and video-amplification circuitry mounted on three printed circuit boards. It is designed to accept an input signal of either sine or balanced complex waveform at a minimum level of 100 mV r.m.s. and is arranged to divide the input signal by factors of 1, 2 or 4 to provide an output at a level which is suitable for the direct operation of the SA. 505. In addition, facilities are included such that the counting period of the SA. 505 can be automatically modified so that irrespective of the division ratio selected the unknown frequency is displayed directly. This is achieved by the use of d.c. logic switching and enables frequencies to be measured with an overall accuracy of ± 1 count $\pm$ stability of frequency standard employed. In this case the indicated count is dependent upon the division ratio selected.

Circle **6** *for further details.*

Portable D.C.—15 Mc/s Oscilloscope

THE Solartron CD 1015 oscilloscope is a small, high performance oscilloscope designed for a wide range of laboratory and field applications. The CD 1015 is particularly useful for design, development and testing of computers, digital data systems and counters.

This instrument employs a high sensitivity p.d.a. cathode ray tube Type 900E operating from a stabilised 4 kV giving crisp, bright displays at all sweep speeds.

The Y amplifier has a bandwidth of d.c.—15 Mc/s with a sensitivity of 50 mV/cm—50 V/cm. A built-in a.c. pre-amplifier extends the sensitivity to 5 mV/cm at 8 Mc/s and 500 μV/cm at 900 kc/s. A 0·25 μsec Y signal delay allows leading edges of fast pulses to be displayed.

The time-base range of 500 nsec/cm—200 msec/cm is covered in 18 calibrated ranges. A fine control gives a maximum sweep rate of 50 nsec/cm. The time-base can be triggered from an internal or external source, positive or negative slope. A level control enables the sweep to be triggered from any point on the triggering waveform.

" Auto-trigger " facility allows the time-base to be triggered automatically from signals of varying slope and amplitude. " HF Sync " provides synchronisation up to 15 Mc/s.

A rear-mounted socket enables external time-base waveforms to be applied to the X amplifier, which has a bandwidth of d.c.—1 Mc/s and a sensitivity continuously variable from 100 mV/cm—1 V/cm. A hinged chassis construction is incorporated to give maximum accessibility. Other features are—provision for external brightness modulation—accessible Y plates—8 × 4 cm graticule with variable illumination. Overall dimensions are: $13\frac{1}{2} \times 10 \times 19$ in. (35·5 × 25·5 × 48·5 cm); Weight 36 lb (16·2 kg).

Circle **7** *for further details.*

High Voltage, High Current Stabilised Power Supply Units

THREE basic models of power supply units from Electronic Machine Co. Ltd. have been designed to give a high voltage, high current stabilised power supply covering a range of from 0—5,000 volts with a current of up to 500 mA, the three units being supplied as follows:

(a) 0—1 kV
(b) 0—2 kV
(c) 0—5 kV

In all three units the output voltage is continuously variable with a single control from 0 V to the full rated voltage, the full output current may be taken down to 5% of full output voltage, the output voltage variation is less than $\pm$ 1% for full load change, and the ripple content less than 1 V r.m.s. The high voltage circuits are isolated from earth and may be run up to 10 kV above it.

The units are supplied for either single or three phase input. Special units can be supplied to meet with particular requirements.

Circle **8** *for further details.*

Turbulence Detection Unit

THIS instrument has been designed principally for turbulence detection studies on the surface of ship models during normal resistance testing in model towing tanks. The system may be used in other liquids and gases when it is required to detect turbulence without obstructing the flow.

Twenty small platinum-film surface-sensing probes are inserted into the surface under study with the films flush with the surface. The probes may be fitted quickly and joined to a small junction box inside the model. The control unit, which may be carried in the model, or remotely on the carriage, switches the probes manually or automatically, after pre-set time intervals from 1 to 60 seconds so that the characteristic flow signals may be fed into a 1, 2 or 4 channel chart recorder or an oscilloscope; alternatively the signals may be made audible.

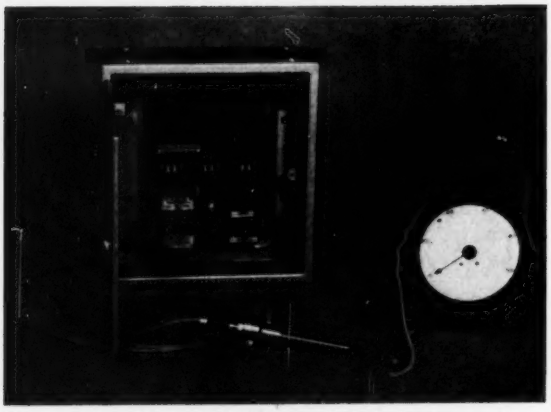
The control unit contains a uniselector and various switching devices permitting the following scanning operations:

1. Single channel, probes 1 to 20 serially
2. Two parallel channels, probes 1 to 10 and 11 to 20 serially in each channel
3. Four parallel channels, probes 1 to 5, 6 to 10, 11 to 15 and 16 to 20 serially in each channel.

The built-in timer can be set to time intervals so that the read-out of each probe in turn may be recorded over periods from 1 to 60 seconds; the probes may be stepped manually by a push-button. The sequence can be stopped by a stop button, or re-set to zero by a re-set button. A sensitive galvanometer is built in for the initial balancing of the twenty probes against the reference voltage. Twenty pre-set potentiometers are arranged in sequence to obtain balance on the resistance of each probe. A number display shows which probes are inserted.

It is available from Lintronic Ltd.

Circle **9** *for further details.*



Pressure transducer and d.c. amplifier/indicator unit

Pressure Transducer and D.C. Amplifier/Indicator Unit

INDUSTRIAL INSTRUMENT SERVICES CO. are introducing a d.c. amplifier unit, Model PTA/1, for use with the " Dynisco " Type PT/58 pressure transducers supplied by them for the measurement of thermoplastic pressures in extrusion machines, etc.

The signal from the transducer strain gauge bridge network feeds into a transistorised d.c. amplifier unit, the output of which is connected to a moving coil milliammeter calibrated as a pressure indicator. The latter has a 240° scale, 9 in. long, and gives a 2 mA full scale deflection for a 20 mV bridge output at full scale pressure. This system has been developed as an improvement to the simpler method employing a galvanometer type indicator connected directly across the bridge output, where performance is restricted by virtue of the low output millivoltage from the transducer relative to the output resistance of the bridge network. The model PTA/1 overcomes these disadvantages and provides a very fast and accurate response to small changes in mean working pressure.

The amplifier incorporates an electrical self-balancing system between output and input, thus providing a fast and stable null-balance system of measurement.

The amplifier unit is housed in a sheet steel box, approximately 13 × 12½ × 4 in. depth, with easy access to adjustable pre-set controls for range span adjustment, bridge excitation volts, and bridge balance. The unit is designed for operation on a standard 240 volts, 50 cycle mains supply, and provides Zener diode stabilisation for both amplifier power source and bridge voltage supply.

Circle **10** *for further details.*

" AutoDip " Resistance Operated Level Control For Liquids

THE " AutoDip " equipment is designed to provide single or two point control of the level of liquids in containers. The units are suited to applications where the container depth necessitates the use of long probes; for example, in the case of sumps or deep storage banks. No restriction is placed on the length of the probe which may be constructed of any electrically conductive material appropriate to the liquid involved.

The " AutoDip " operates on the change in electrical resistance as the liquid contacts the probe. This change in condition is detected and used to operate an internal relay. Fail safe features are inherent in the design of the unit which will operate over a resistance range from zero to 500,000 ohms, making the equipment suitable for use in most electrically conductive liquids.

The " AutoDip " represents a further extension to the range of level control and indicating equipment produced by Lancashire Dynamo Electronic Products.

Circle **11** *for further details.*

Chromatogram Sample Holder

CARL ZEISS have developed a new sample holder for the chromatogram attachment to their spectrophotometer P.M.Q. II.

This sample holder will accommodate strips of up to 200 cm long.

The strips are wound on spools and, depending on the thickness of the paper, can be up to 200 cm in length. The spools have a clamping device for winding, and a spring-loaded plunger which acts as a brake and ensures continuous tautness of the paper strips.

The spool may also be adjusted vertically and clamped at any desired height. The test strip is held in place between plates of metal and Plexiglass. These plates are provided with window cutouts, and holes through which the strip can be marked by means of a needle.

The agents for Carl Zeiss in this country are Degenhardt Co. Ltd.

Circle **12** *for further details.*

Dual Electrode Leveltron Controller

A NEW version of the Leveltron industrial level controller has been released by Thomas Industrial Automation Ltd. This controller is for use with two electrode units, one mounted at high level and one mounted at a low level position in a vessel, tank, or silo. Special contacts on the relay of the unit switch the electrodes into the circuit as required so that, in effect, only one control unit is required for both high and low level control of pumps, conveyor motors, valves, etc.

The control unit has one relay only which will become de-energised when the high level position is reached by the material, and will re-energise when the material has fallen below the low level electrode, thus providing an automatic interlock between the two levels. The main advantage of this system is the saving in capital outlay, since, although two electrodes are required, only one control unit, as explained above, is necessary.

The instrument can be used with any of the standard range of T.I.A. electrodes, and the distance between controller and electrodes can be as much as 50 ft.

This new Leveltron, Type CS 101, can be housed in a sheet steel or cast iron case, and delivery effected within four weeks.

Circle **13** *for further details.*

Silicon Diffused Junction Rectifiers

RECTIFIED d.c. output currents up to 1·8 amperes per rectifier cell along with extremely low reverse leakage (500 μA at rated p.i.v. at 150°C) are now available in a a new diffused junction " top hat " rectifier series from

International Rectifier Co. (G.B.) Ltd. Designated Types X10B1 to X10B6, the new series will provide forward currents up to 1·8 amperes (when mounted on heat sink) or 1·3 amperes (without heat sink in air) over a peak inverse voltage range from 100 to 600 volts.

All units are particularly suited for magnetic amplifier applications where low leakage is a design parameter. Additional characteristics include very low forward voltage drop (1·10 volts max. at rated current at 25°C) and high surge current capabilities (40 amp peak at 0·01 sec). All types have an operating temperature range from −65 to +175°C, and feature rugged, hermetically sealed, welded construction.

Circle **14** *for further details.*

Co-axial Relay

DESIGNED in conjunction with the B.B.C., the new A.10 high power co-axial relay from B. & R. Relays can handle 1 kW of r.f. power using type " C " or type " N " connectors.

Contacts are of the single change-over type and of silver palladium. Coils are suitable for voltages up to 50 V d.c. and characteristic impedance 50 ohms. The v.s.w.r. is less than 1·09 and the cross talk is 63 dB and down, both at 65 Mc/s. The A.10 is at present being used widely as an aerial change-over switch at unattended v.h.f. satellite transmitters.

Circle **15** *for further details.*

Helazipp Tubing

HELAZIPP, developed by Hellermann Ltd., is a flexible p.v.c. tape with interlocking beading along each edge, which when wrapped round the length of cables will interlock simply by zipping the two sides together.

This new plastic cable-covering, specially designed for varied atmospheric conditions, is dust and moisture proof, extremely tough and light-weight.

Available in either black or transparent, Helazipp allows wires to be traced without any difficulty or without having to undo work previously carried out, by un-zipping the Helazipp covering. It can also be used in place of conduit or in certain circumstances as a cover for conduit giving protection from corrosion.

The wall thickness of Helazipp is 0·015 in. to 0·020 in. in the following sizes—(Inside diameter) $\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., $1\frac{1}{2}$ in., 2 in., $2\frac{1}{2}$ in., and 3 in.

Circle **16** *for further details.*

Electrometer Measures Down to 10^{-15}A

A PRECISION electrometer capable of measuring ultra low currents and voltages is announced by The Wayne Kerr Laboratories Ltd.

An outstanding feature of the new instrument, which is known as the M141, is its ability to measure while drawing virtually no energy from the measurement source. The full scale ranges are 1 mV, 10 mV, 100 mV, 1 V and 10 V d.c. and, using three standard resistors, from 10^{-15} A f.s.d. to 10^{-6} A f.s.d. Input resistance is greater than 10^{16} ohms, and the input capacitance is approximately 1 pF, with a maximum charge sensitivity of 3×10^{-15} coulomb.

These high levels of sensitivity and stability are matched by the speed of reading. When measuring values as low as 10^{-15} A up to 10^{12} ohms, the time constant is determined only by the degree of integration required to remove the inherent fluctuations which are due to the statistical nature of electron flow.

When the order of the measured quantity is known, the first digit of the reading can be transferred to the decade control, and the meter will then indicate the second and subsequent digits. This feature provides a measurement accuracy equivalent to 0·1% of full scale deflection on all ranges, and also serves as a " backing-off " device which enables small variations to be measured with a high degree of discrimination.

The M141 operates on 115 or 230 V a.c. supplies. It operates on the dynamic capacitor principle. The dynamic capacitor operates as a high-Q resonant system at 1,000 c/s, thus avoiding the errors associated with capacitors driven at mains frequencies. The instrument is so constructed that calibration and set zero adjustments can be effected without disturbing the external connections, thus eliminating the possibility of errors caused by changed field conditions. This is made possible by the use of solenoid-operated switches. A Weston cell is fitted internally, and is automatically brought into circuit for calibration checks.

Although designed primarily for use in electronics and physics laboratories, the M141 can be used also in the chemical, biological and industrial fields.

Circle **17** *for further details.*

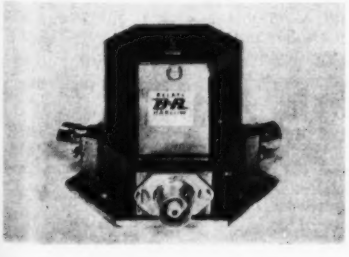
Silicon Power Diodes

HS 3100 Series high conductance, low leakage, 200 mA diode is available from Hughes International for high voltage applications. It is available in a p.i.v. range 300—1,000 volts.

Also available is the Type 1N645-9 sub-miniature 400 mA diode/rectifier for power supply and switching applications where small size and reliability are prime considerations.

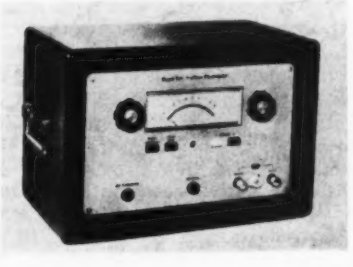
Circle **18** *for further details.*

High power co-axial relay



Helazipp tubing

Precision electrometer



Plastic Film Capacitors

Two types of plastic film capacitor with improved characteristics and designed to work under conditions of extreme humidity are now included in the G.E.C. range offered by Salford Electrical Instruments Ltd. They are sealed polyester capacitor, Type A596, and an encapsulated polystyrene capacitor, Type A597.

The polyester capacitor, Type A596, has an extended range of temperature working and is available in the range 0·05 mF to 2·0 mF with a rated d.c. working voltage of 150 volts. This capacitor has been developed to meet the requirements for a non-metallic cased capacitor with a high insulation resistance, good charge retention characteristics and a high stability of capacitance over a wide range of ambient temperature. The sealing and construction of the capacitor ensure that it will meet the H.1 requirements of the proposed B.S. specification for polyester capacitors.

The polystyrene capacitor, Type A597, is available in the range 150 pF to 510,000 pF at d.c. voltage ratings of 125 V, 350 V, 750 V, and 2,000 V. An important characteristic of this range of capacitors that will be of interest to the designer of precision filter networks, is the close control of temperature coefficient that is achieved. The A597 is fully encapsulated and will meet the H.1 humidity requirements of RCS 137.

Circle **19** *for further details.*

Capacitive Type Level Indicator

A CAPACITIVE measuring process has been developed by the firm of Grieshaber Brothers for continuous remote measurement of contents-level in silos, bunkers, and containers of all kinds. The process is based on an a.c. operated emitter and a measuring amplifier.

The emitter consists of an electrode, usually rod shaped, which is fitted inside the container. The electrode and the wall of the container together form a capacitor. In the head of the electrode there is an electrical device consisting of an impedance converter for transforming a low-impedance high-frequency input voltage and a bridge arrangement in which the variable arm is the capacitance between the electrode and the wall of the container.

Any alteration in the contents-level in the container causes a change in the capacitance between electrode and container wall which simultaneously causes a change of voltage at the bridge. The resulting voltage drop at the bridge is rectified by a silicon rectifier. This d.c. voltage, which changes in perfect linearity with changes in contents-level, is taken to a high-impedance, stabilised, two-stage amplifier. At the output of the amplifier are one or more indicating instruments which show continuous measurement of the contents-level. The measuring amplifier and an h.f. generator for supplying the bridge circuit in the electrode head are housed together in a dust-proof and spray-proof case, which can be installed at any desired distance from the electrode.

In place of the measuring amplifier for continuous measurement of contents-level, a switching amplifier can be installed which releases a switching pulse through a thyratron-controlled relay when a predetermined contents-level is reached.

Current designs of capacitance measuring systems for measuring the contents-level in containers normally make use of capacitive de-tuning of an h.f. resonance circuit (e.g. oscillator circuit) and require that the a.c. supply voltage to the electrode be connected by a screened cable with specially low capacitance (e.g. coaxial h.f. cable). This means that the length of cable between the oscillator and electrode is in practice restricted to a few yards.

The Grieshaber process has the advantage that, because the h.f. voltage is supplied to the electrode at low impedance and the d.c. voltage is connected back at relatively high impedance, any distance between the electrode inside the container and the measuring amplifier which is likely to be required in practice can be covered without affecting accuracy of measurement. The connection between the electrode and the measuring amplifier can be made with ordinary electrical cable without special screening.

With continuous contents-level measurement a change of 3 pF is sufficient to move the indicator to the end of the scale. If the apparatus is of the type that releases a switching pulse a change of capacitance of 0·5 pF is sufficient for operation.

The indicator is available in this country through International Engineering Concessionaires Ltd.

Circle **20** *for further details.*

Regulated Power Supply Units

A RANGE of power supply units is available from Dukes & Briggs Engineering Ltd.

Type " O " is normally supplied in skeleton form for building into user's equipment. The space requirements are 9 × 6 × 4 in.

The supplies are 110 V or 250 V, 50/60 c/s, single phase a.c. and the output is 250 V at 0-90 mA or 250 V at 0-60 mA. The stability factor (is ½% change in mains/% change in output) is 400:1.

Type T12 transistorised power supply is designed particularly for use in technical schools and laboratories. It operates from 110/250 V, 50/60 c/s, single phase a.c. The output is continuously variable from nominal 6 V to 12 V at 0 to 1 amp. The stability factor is 1 in 1,000.

Type T15 operates from the same supplies as the Type T12 with an output continuously variable from nominal 6·5 V to 15 V at 0 to 1 amp. The stability factor is 1 : 625.

Circle **21** *for further details.*

Triple-diffused Planar Transistor

RCA-2N2102 silicon n-p-n triple-diffused planar transistor is a direct replacement for the 2N1613 family of transistors.

The breakdown voltage (BV_{CBO}) is 120 volts at I_C = 0·1 mA
Saturation voltages are:
(V_{CE}sat)—0·5 volt max. at I_C = 150 mA
(V_{BE}sat)—1·1 volts max. at I_C = 150 mA
Output capacitance (C_{ob}) = 15 μμF max.
Wideband noise figure = 6 dB max.
Maximum dissipation rating = 5 max. watts
Switching speed = 30 mμs max. (non-saturated mode)
Beta controlled over 5 decades of collector current from 10μA to 1 A
Leakage currents: (I_{CBO}) = 2 mμA max. at V_{CB} = 60 volts
(I_{EBO}) = 2 mμA max. at V_{EB} = 5 volts
The nail-head bonding withstands 20,000 *g*.

Circle **22** *for further details.*

Datex Analogue-Digital Converters

ELLIOTT BROTHERS (LONDON) LTD. are now able to supply the whole range of Datex analogue-digital converters and associated units.

These devices are used extensively in data-handling applications in ground and air navigational systems and throughout the industrial process-control field.

Datex encoding units are rotary-pattern, coded-type commutators which convert angular position co-ordinates into digital electrical signals. They have powers of resolution up to 1 part in 10^6 or better and their small size makes them easy to package and protect.

Datex auxiliary equipment is designed to accept the coded output of the digitiser and convert it into suitable form for display, recording or further processing. These units can either be electro-mechanical or electronic devices. The output normally takes the form of a digital (decimal) lampbank display, printed records, paper-tape or punched cards.

Systems have also been designed to accept digital commands and to translate these into movements of the encoder.

Circle **23** *for further details.*

Electronic Tachometer

THE Reilly tachometer, Type 1, is an instrument for measuring rotational speed in two ranges, 10,000 to 200,000 and 1,000 to 20,000. The principle of operation is to project light on to a shaft which has been previously marked with a spot, and to pick up the reflection with a photo-electric cell, so that one electric impulse per revolution of the shaft is obtained. The meter then indicates the number of pulses occurring per unit time, and hence the speed of rotation. The accuracy of indication is better than 2% of the full scale deflection, and is reasonably unaffected by external conditions, e.g., mains variations, ambient light or location of probe. Downward extension of the range can be effected by having more than one spot on the surface being investigated.

The instrument is in two parts, the probe unit, and the indicator unit. The indicator is a cabinet, $4\frac{1}{2} \times 4\frac{1}{2} \times 8$ in., which houses the meter, amplifiers and power supplies, and has a socket for the probe, which contains the light source and pick-up. The probe has very small dimensions which enable it to be located in confined spaces near to the shaft surface which is being observed. If this is inadmissible, due to local conditions, an extension piece can be fitted which can bend corners and allow the probe to be located out of harm's way. The range is changed by operation of a switch on the indicator unit, which also switches the instrument off in the third position.

This instrument is basically a frequency meter, for the range 16 to 3,300 cycles per second, and, as such, is not limited to measuring rotational speeds as described, but will give the mean rate of occurrence of any repetitive phenomena, which can be converted into suitable impulses.

The supply voltage required is 105 to 250 volts, 50 to 60 cycles, 12 watts, a mains tapping adjustment is included inside the indicator unit.

Circle **24** *for further details.*

Delay Lines

COSSOR RADAR & ELECTRONICS LTD. have extended their existing range of magnetostriction delay lines. New products now available permit dynamic storage of pulse information for periods of five microseconds to 1·5 milliseconds.

The lines consist basically of a nickel tube, the ends of which are terminated in matched p.v.c. loads. Transducers, in the form of encapsulated ferrite cored coils, are threaded on to the nickel tube. When a pulse is applied to the input transducer, a magnetic field pulse is produced along the axis of the nickel tube. This, in turn, creates a strain pulse which is then propagated in both directions along the tube at a velocity equal to the speed of sound in nickel. As this strain pulse passes through the pick-off coil, an output pulse is generated. By varying the distance between the input and output transducers, adjustment of delay time can be made in circuit without disturbing the unit.

If required, a number of pick-off coils can be arranged along the delay line. In this way, several output pulses can be produced at discrete time intervals after the occurrence of a single input pulse. The number of output transducers that can be threaded on to a particular delay line is limited only by the physical length of the nickel tube and the longitudinal dimensions of the transducers. The lines thus find useful application in the production of binary coding and decoding sequences, selective gating systems, sequential calling devices, shift registration, series to parallel and/or parallel to series converters, etc.

The complete delay lines can be supplied mounted in metal containers which, in addition to protecting the unit, provide a shield between the delay line and adjacent circuits. In addition to a number of standard ranges, Cossor magnetostriction delay lines can be supplied to customers' special requirements.

Circle **25** *for further details.*

Constant Rate Feed Scales

W. & T. AVERY LTD. have available a new range of constant rate feed scales which are applicable for the proportioning and feeding of materials into continuous or batching processes.

These scales will handle any reasonably free-flowing granular, or very free-flowing powdered material at a constant, predetermined rate by weight.

The heart of the control system is a mechanical gate control mechanism which is totally enclosed and dust-sealed within the scale headwork. When the density of material fluctuates, smooth rapid corrections are made instantly through the positive proportional control which reduces hunting to a minimum.

The weigh conveyor is mounted as a self-contained unit on the weighing system and totalised output is provided on a 7-figure counter.

Setting of the motor-driven conveyor is carried out through an infinitely variable gearbox which can be controlled either at the scale or remotely.

Visual indication by a scale indicator provides a check on the accuracy of the machine's performance at all times.

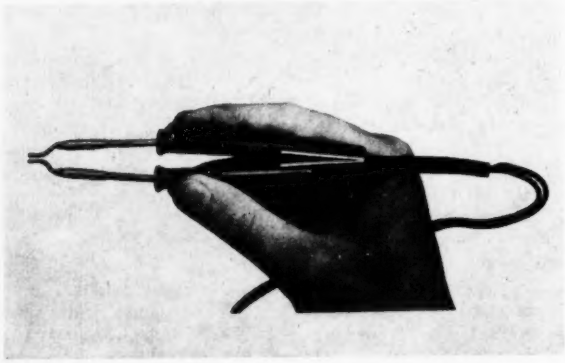
Rate setting by variable belt speed has made remote control a practical operational feature. The operator

can set the scale to feed at a predetermined rate indefinitely, providing an adequate supply of material is continuously maintained in the feed hopper.

Alternatively, the operator can select the required rate of feed and set the scale to automatically cut-off when an exact weight has been delivered. The totaliser provides a visual record of the amount of material that has been fed across the scale.

Where two or more scales are installed, interlocking can be incorporated so that should any feed supply faults develop, all scales would automatically stop.

Circle **26** *for further details.*



Micro-miniature soldering tweezers

Micro-miniature Soldering Tweezers

A SOLDERING instrument has been developed by Oryx Electrical Laboratories Ltd. to meet the need for precision soldering in laboratories and on production lines with micro-miniature circuit modules, diodes, transistors, other semiconductors, relays, etc.

The instrument is in the form of a pair of tweezers having 1/32 in. tips and separate heating elements to both tips. The long life elements are as provided for the range of Oryx standard miniature soldering instruments and operate at up to 554°F tip temperature from 6 volt supply.

Light to handle and requiring only minimum finger pressure, these tweezers provide unobstructed view at all times for close precision soldering. An operator can hold work and give simultaneous heating on both sides of a circuit module with only one hand. It is claimed that heating times are considerably reduced and cold joints are virtually eliminated.

These soldering tweezers are being marketed in the U.K. by W. Greenwood Electronic Ltd.

Circle **27** *for further details.*

Control Valve

ETHER LTD. have added to their range of control valves Type VPH, which has been developed for hydraulic and pneumatic servo duties. It is capable of operating in the pressure range of 250 to 3,000 lb/in² and incorporates ⅜ in. diameter orifice and ⅜ in. B.S.P. connections. This valve is available in brass or stainless steel construction. Brass construction, Type VPH/B, is priced at £15 0s. 0d. list, and stainless steel construction, Type VPH/S, at £21 0s. 0d.

Circle **28** *for further details.*

P-N-P Alloy Junction Transistors

THE NKT 501-504 series of high current, high power, p-n-p alloy-junction germanium transistors in an industry-standard TO-36 encapsulation which have been designed by Newmarket Transistors are intended for amplification, control and switching applications in the industrial and services field where quality and reliability are mandatory.

The range comprises four types:

NKT 501	High-voltage, very high-current transistor. Voltage rating 60 V. Beta at 25 A greater than 12
NKT 502	Medium-voltage, very high-current transistor. Voltage rating 30 V. Beta at 25 A greater than 12
NKT 503	High-voltage, high-current transistor. Voltage rating 60 V. Beta at 10 A greater than 12
NKT 504	Medium-voltage, high-current transistor. Voltage rating 30 V. Beta at 10 A greater than 12.

The low saturation voltage results in low-self dissipation when used for switching applications. The drive voltage for peak collector current is low and distortion is minimised by controlled beta fall off.

All units are cold welded for reliability, stringent surface treatment and high temperature ageing ensure parameter stability. Each unit is tested 100% for electrical characteristics.

Circle **29** *for further details.*

Instrument Grade Organo-silicate Liquid

HYGROTHERM ENGINEERING LTD. are now marketing an instrument grade organo-silicate liquid, HYFIL A.

HYFIL A is a specially processed organo-silicate liquid which has good thermal stability, a wide liquid range and low vapour pressure, making it ideal as a thermofill liquid for thermostats and temperature-indicating instruments operated by fluid expansion.

It has a maximum-use temperature of 360°C which is far above that of any other readily available organic material.

Circle **30** *for further details.*

Multi-channel Analogue and Digital Data Recorder

THIS equipment is designed by Lintronic Ltd. to the specifications of the Meteorological Office for the continuous recording of radiation from the sun and sky, daylight intensities and diffusion. It is installed at the Kew Observatory.

A series of low level signals from transducers, ranging from −1·5 to +5 millivolts are fed through the recorder at a rate of 12 per minute. Each signal is registered on a chart recorder and converted into three digit numbers through a digitiser for visual display and punched out on to paper tape. The unit records for three days without attention and is equipped with a 24-hour digital clock which records "Time" prior to each minute of measurement. The tape output format is ready for presentation to a digital computer for calculating daily average of the quantities measured.

Circle **31** *for further details.*

Ferrite Cores

Two toroidal 0·050 × 0·030 × 0·015 in. ferrite cores for use in coincident-current magnetic-memory devices are available from RCA. They measure 0·050 × 0·030 × 0·015 in.

The 229M1 has very high switching speed and moderate driving-current requirements. At a full driving current of 800 mA, this core has a switching time of approximately 0·55 μs.

The 230M1 has high switching speed and low driving-current requirements. At a full driving current of 440 mA, the 230M1 has a switching time of approximately 1 μs and is particularly useful in magnetic memories having operating cycles of 4 to 6 μs.

Circle **32** *for further details.*

Smoke Control Equipment

PHOTRONIC CONTROLS LTD. are manufacturing a range of smoke control units designed to The Clean Air Act, 1956.

Smoke Alarm Type SA. This basic unit will provide a visual and audible warning when smoke exceeds a pre-set density. The principle of operation is for a light beam to be projected across the flue or chimney on to a photo-electric cell. This cell is connected to a control unit and as smoke breaks the beam a varying current is passed to the control until an " alarm point " (which can be set by the operator) is reached and then a red light and alarm bell are energised. The type of photocell used is capable of withstanding ambient temperatures up to 70°C. Only 2 in. diameter holes need be cut in the flue or chimney and units are available for any size of installation from a few inches to 40 ft diameter. The price is £25 for a complete set and delivery is 4—6 weeks.

Smoke Indicator Type SI. This unit is basically similar to the Type SA unit and has the same principle of operation and advantages. In addition it has a 10 in. indicating meter on which the level of smoke is shown at all times. A red pointer is also provided to show the " alarm position " so therefore the operator can see on this 240° scale meter the density of smoke being emitted and how near the alarm point the installation is at any time. The price of this unit is £50 for a complete set. Delivery is 4—6 weeks.

A bell muting switch can be fitted which will stop the bell from ringing by the depression of a push-button whilst keeping the red warning light energised. When smoke ceases to be made the unit will automatically re-set ready for the next operation. A variety of recorders are also available to work in conjunction with these units.

Circle **33** *for further details.*

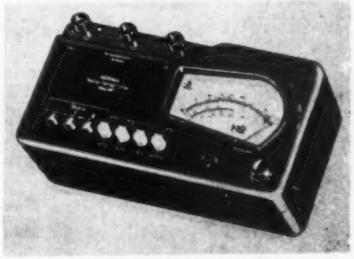
Wander Connection Jack

FOR a hanging connection where the lead is " hot ", the Sealectro " Press-Fit " Type SKT-13C1 is the smallest such jack yet available. Measuring less than $\frac{1}{8}$ in. in diameter, it provides a single female contact receptacle used in conjunction with the mating Type FT-SM-125 " Press-Fit " feed-through mounted in the chassis.

Circle **34** *for further details.*

Insulation Tester

THE Norma insulation tester Model 667 has available four test voltages, 100, 250, 500 and 1,000 V. The range of up to 10,000 MΩ is divided into three scales, each of which can be multiplied by factors of 0·2, 0·5 or 2. Currents up to 1 mA are supplied by means of a transistorised control circuit. The method of operation of the tester is simplified by means of the push-button selection of test voltage, range and multiplying factor. The scale is 3·4 in. long and accuracy is ±2·5% f.s.d.



" Norma " insulation tester

The power supply is from two built-in 4½ V dry cells with checking facility. The dimensions of the tester are 8½ × 4½ × 5 in. and the weight is 5 lb.

Range

	100 VOLTS	250 VOLTS	500 VOLTS	1,000 VOLTS
Scale 1	0 to 0·1 Mohm	0 to 0·25 Mohm	0 to 0·5 Mohm	0 to 1 Mohm
Scale 2	0·05 to 1 Mohm	0·125 to 2·5 Mohm	0·25 to 5 Mohm	0·5 to 10 Mohm
Scale 3	1 to 1,000 Mohm	2·5 to 2,500 Mohm	5 to 5,000 Mohm	10 to 10,000 Mohm

The insulation tester Model 667 is available in this country from Croydon Precision Instruments.

Circle **35** *for further details.*

Automatic Systems Analyser

THE automatic systems analyser of Honeywell Controls Ltd., although primarily designed for testing aircraft electronic systems, is adaptable to other fields of activity such as process control systems.

The model recently demonstrated is used to ensure that an aircraft's electronic controls are operating correctly. It can do all the tests needed to verify that an aircraft is in flying condition automatically in a matter of minutes.

The analyser performs one test per second. Electronic systems are checked individually and in combination with each other. Total test time is speeded up by scheduling tests in an orderly but instantaneous routine.

The skills required to operate the automatic systems analyser are less than those maintenance specialists would have to have for manual checks. Thus, the analyser liberates specialists for more important tasks and will allow the reduction of training time of maintenance crews.

The analyser carries out its tests by using information punched out on tape. The required programme tape is placed in the tape reader which allows it to control the test circuits. Various operational manoeuvres are simulated, and the system indicates whether the circuits are working correctly. The object of the tests

is to isolate whatever fault may be found by tracing it down to a system circuit or to a replaceable unit. Signals from the system being checked are compared with predetermined standards of acceptability.

Not only does the analyser test the aircraft, but it tests itself for possible errors. The faults in the aircraft are isolated on the tarmac without having to wheel it into the hangar. The trouble is diagnosed and indicated to the operator. The analyser does the same thing within its own system to ensure that its tests are valid.

Circle **36** *for further details.*

Zener Diodes

THE HS2000 Series Zener diodes from Hughes International is a sub-miniature 250 mW series in preferred voltage range 2·7—33 volts. It features low dynamic impedance and temperature coefficient, and has a standard tolerance ±5% which is also available to ±15%.

Hughes report that a 700 mW range is going into production shortly, and samples are available now.

Circle **37** *for further details.*

Totalising Belt Weighers

A NEW range of totalising belt weighers has been developed by W. & T. Avery Ltd.

These scales are adaptable to meet a wide variety of requirements for totalising the weight of material passing over a conveyor belt. The machines are designed to fit into an existing conveyor system and are suitable for either horizontal or inclined installations.

All machines are built into a robust steel framework designed for incorporating into an existing system.

Ingenious design has produced a simple, reliable, robust and trouble-free mechanical totalising mechanism, totally enclosed and dust-sealed within the scale headwork.

Totalised weight is shown on a 7-figure counter.

Pendulum type indication provides continuous indication of rate of feed.

Electrical signals are obtainable from the belt weigher which enables associated plant to be automatically regulated according to the rate of flow of material.

Remote totalising and indication or recording of rate are also available.

Circle **38** *for further details.*

Counter

SIX in-line projection indicators, with automatic decimal point and caption indicator, are some of the features of the latest transistorised counter from Advance Components Ltd.

The new counter, the T.C.1.A., is a laboratory grade instrument designed for the measurement of time, period and frequency and the counting of regular or random impulses from 0 to at least 10^6 per second.

The T.C.1.A. uses a thermally compensated internal crystal oscillator enabling accurate measurements to commence immediately the instrument is switched on.

There is accommodation for an external standard and self-checking facilities are incorporated to test the operation of all circuitry. This is carried out by a ten second count of a sub-division of the crystal frequency.

Transistorised counter

A sensitivity control enables discrimination to be made against spurious signals of lower amplitude. Signals as low as 100 mV r.m.s. and up to 250 V r.m.s. at frequencies from 10 c/s to at least 1 Mc/s may be measured. The v.l.f. input enables measurements to be made below 10 c/s down to virtual d.c. Pulse width measurement can also be made. Output timing pulses, variable in decade steps from 10^{-1} to 10^6, are an additional facility and there is provision for an external recorder.

Frequency range:	0 to 1 Mc/s
Time measurement:	From 3 μs to 2,777 h
Period measurement:	Duration of 1 to 10^5 periods of input waveform up to 50 kc/s
Output timing pulses:	10^{-1} to 10^6 p.p.s. in decade steps from 300 ohm source. (4 V peak approximately)
Time standard:	
Internal:	Thermally compensated to 4 Mc/s crystal oscillator by A.T.E. divided down to 1 Mc/s. Accuracy ± 1 part in 10^6 over a temperature range 10°C to 30°C and ±5 parts in 10^6 from 0°C to 40°C
External:	Any frequency in the range 1 kc/s to 1 Mc/s, input level greater than 1 V r.m.s. up to maximum of 10 V r.m.s.
Display accuracy:	± 1 count ± accuracy of standard frequency
Sensitivity:	
Normal input	10 c/s—1 Mc/s. Sensitivity control fitted, input impedance 100 kΩ. Sensitivity better than 100 mV r.m.s. on single wave drive. Maximum input level 500 V peak
V.L.F. input:	0—1,000 c/s. Positive going waveform + 2 V peak max. input level 50 V peak
Frequency measuring period:	0·1, 1·0 or 10 seconds
Display time:	1 to 5 seconds, or "hold"
Repetition of count:	Manual, automatic or external control
Output to external recorder:	Staircase voltage waveform for each digit, in nine steps between −0·75 V and −3 V with a source impedance of 2·5 k ohm, a −6 V line (100 mA rating) stop pulse, electrical reset input
Dimensions:	Length 16½ in., height 10½ in., depth 10½ in. (42 × 26·7 × 26·7 cm)
Weight:	28 lb (12·7 kg)
Price:	£395 net in U.K.

Circle **39** *for further details.*

Miniature Synchronous Single Cam Timer

ELECTRICAL REMOTE CONTROL LTD. are manufacturing a simple inexpensive switch for automatic oil firing plant, vending machines, etc. It has small overall dimensions and weighs 11½ oz. The time cycles range from three seconds to 24 hours. Where the timer motor supply is the same as that of the switched load, the timer can be wired to give single cycle stop operation.

Operating voltages are 110, 200/250 volts, 50/60 cycles. The switch ratings are 5 amp at 250 V a.c., and 5 amp 24 V d.c.

Delivery time is 4/5 weeks

Circle **40** *for further details.*

Remote Readout for Digital Voltmeter

ELECTRONIC ASSOCIATES LTD. has announced a remote readout, any number of which can be hooked up to a transistorised digital voltmeter. The readout assembly, with storage and decoder cards, measures 3½ by 19 by 17½ inches and can be either case or rack mounted. It accepts binary-coded-decimal 8421, gives decimal visual readout and supplies binary-coded-decimal and decimal data outputs. The instrument uses standard output level and has a built-in power supply unit.

It can be used with any voltmeter that supplies binary-coded-decimal 8421 and is available for use with other codes, such as 4221. It is also available with up to seven digits for special applications.

Circle **41** *for further details.*

Hall Effect Devices

Two magnetic sensing elements made by F. W. Bell Inc. are available in the U.K. through Livingston. Laboratories Ltd.

The sensing devices work on the Hall effect principle and versions can be supplied for either axial or transverse field measurements. Because of the small physical size of the elements, the axial is 0·195 in. outside diameter × 0·188 in. and the transverse 0·5 × 0·13 × 0·019in., they can be used in small air gaps and are suitable for a wide variety of applications associated with magnetic field measurements, analogue multipliers, transducers and magnetic circuitry.

Features of the devices are a high Hall output voltage, non-inductive construction, low electrical noise, together with an operating temperature range of −40 to +85°C.

Circle **42** *for further details.*

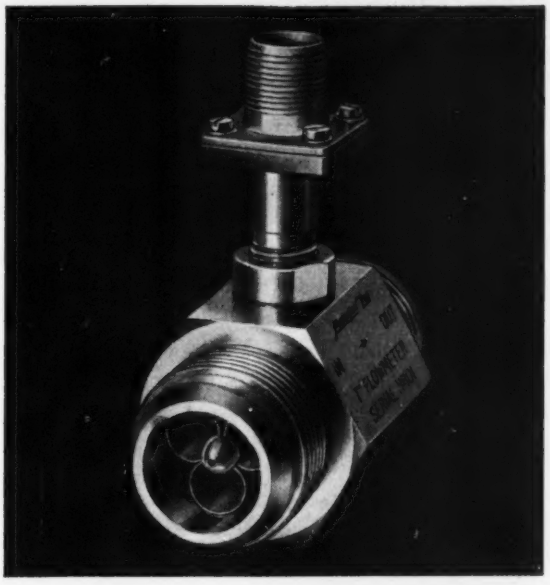
Narrow-range Variable Delay Line

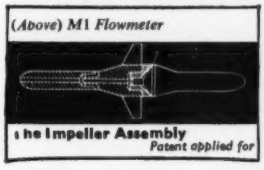
A VARIABLE delay line, Type 301-S104, weighing 1½ ounces and with a total range of from zero to 25 ns ± 10%, has been announced by the General Radio Co.

In addition to the narrow-range feature, the line affords a resolution of 0·06 ns and a pulse rise time of approximately 2·4 ns at maximum delay.

Precious metal wire is used in a distributed winding to assure reliable contact, and shielding is incorporated to minimise capacitive coupling between the input and output terminals. Characteristic impedance of the delay line is 200 ohms ± 20%, and the d.c. resistance is 5·5 ohms ± 20%.

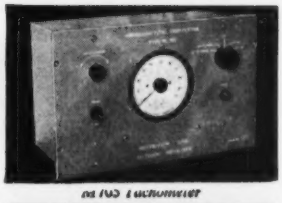
Circle 348 for further information





(Above) M1 Flowmeter

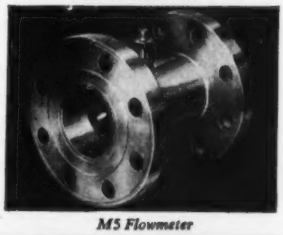
The Impeller Assembly
Patent applied for



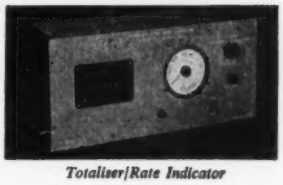
M3 Flowmeter

COMPLETE
FLOWMETER
SYSTEMS

- Repeatability 0.1%, Linearity ± 0.25%
- Low pressure drop (approx. 3 psi).
- Range of pipe diameters from ¼" - 5"
- Flow rates 0.05 g.p.m. - 2000 g.p.m.
- Temperature range — 200°C to + 300°C, dependent on bearing material
- Stainless steel throughout—hygienic, non-corrosive
- For all corrosive and non-corrosive liquids
- Rate - of - flow; integrated quantity; automatic print-out and flow control



M5 Flowmeter



Totaliser/Rate Indicator

Meterflow Ltd. impeller flowmeters employ a unique and exclusive design principle, utilising the pressure drop across the blades to give inherent self-compensation of the down-stream thrust. Meterflow thus gives the highest accuracy at all flows, reliability and long life. Meterflow instruments are available in a wide range of types and sizes for all flowmetering applications in control and engineering, together with all associated electronic equipment to give rate of flow, totalised quantity, and automatic print-out. Please write or 'phone for full details.

Meterflow

Meterflow Ltd.,
Precision Measuring Instruments
North Feltham Trading Estate,
Feltham, Middlesex. *Tel.:* Feltham 5876
An associated company with S.E. Laboratories (Engineering) Ltd.

The miniature variable delay can be used in a wide range of r.f. and pulse-network device applications. It is particularly useful as an r.f. phase shifter and trimmer for phase adjustment in various correlation techniques developed to improve signal-to-noise ratio, and also in radar and space-probe communications. Similar applications prevail in the i.f. channels of multiple-unit steerable-array antennas and in scintillation counter and computer circuits. Additionally, the line can be used as a trimmer in patch-cable delay equalisers and as a substitute for coaxial-cable types of delay networks.

The body diameter of this delay line is 45 mm and its thickness (exclusive of the shaft) is 24 mm.

It is available in this country through Claude Lyons Ltd.

Circle **43** *for further details.*

Non-lethal Flash Tester

A NON-LETHAL 0-5 kV r.m.s. 50 c/s a.c. flash tester is being manufactured by Witton Electronics Ltd.

It is housed in a robust steel case, including carrying handle and incorporating voltage indicating meter, fuses, on/off switch and electronic circuit and terminals.

The equipment is complete with variable voltage setting potentiometer and push to operate button. Maximum short circuit current 1 MA.

Earth lead and high voltage probe are included.

The unit weighs 20 lb and is useful for assembly lines producing transformers, switches, automatic switch and control gear, and domestic appliances, etc.

Circle **44** *for further details.*

Transistor for V.H.F. Amplification

Now available from Mullard in TO-18 encapsulation is a low noise germanium alloy-diffused transistor developed specifically for amplification of frequencies up to 200 Mc/s.

Type-numbered AFZ12, this transistor gives a noise figure of only 6 dB at 200 Mc/s and a power gain in common emitter of greater than 10 dB.

The high stability of its frequency characteristics enables the AFZ12 to be used in a wide variety of video and broad-band high frequency applications.

A current amplification factor of 60 is typical. Maximum collector-base voltage is −20 V and maximum collector-emitter voltage is −10 V at the full collector current rating of 10 mA. In an ambient temperature of 25°C the collector leakage current is typically 1 μA with a collector-base voltage of −6 V. Maximum junction temperature for continuous operation is 75°C and the thermal resistance is 0·6°C/mW, permitting a dissipation of 50 mW in an ambient temperature of 45°C.

The TO-18 encapsulation measures 5·3 mm length by 4·8 mm diameter. An inter-lead shield connected to the metal case is provided.

Circle **45** *for further details.*

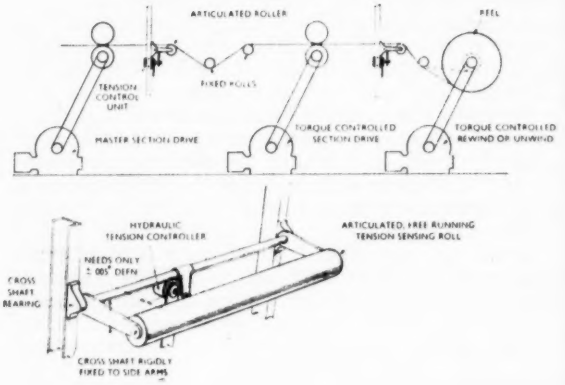
Ceramic-cased Tunnel Diodes

THE operating frequency of tunnel diodes has been raised by a technique of miniature ceramic encapsulation developed by Standard Telephones and Cables Ltd.

The small size (5·6 mm diameter, less tabs) of these new devices and their tab-ended configuration have reduced their inductance to such an extent that a typical limiting frequency of oscillation of 900 Mc/s is now attainable.

A single version, known as the JK30A, is now in production. It is being followed by a new version incorporating a matched pair of tunnel diodes and forming a single integral unit having three tabs. These units are matched for peak current and capacitance and are intended for applications in the computer field. They may be used in high-speed logic and counting circuits or as the threshold amplifier/gate at the input of a pulse amplifier.

Circle **46** *for further details.*



Hydraulic tension control device

Hydraulic Tension Control

HYDRAULIC MACHINERY DRIVES LTD. have developed an automatic tension control device which is applicable to any type of web including extensible plastics. Tension can be controlled to $\pm\frac{1}{4}$ oz/in of web width. Paired with the tension controller is a relief valve which is servo operated by the controller. The function of this valve is to control the main flow of oil to the hydraulic motor driving the next machine section after the controller.

The controller is mounted approximately in the centre of the web run, being fixed firmly by its mounting flange. The thrust pin of the controller rests against a lever fixed to a cross shaft supported at each end by self-aligning anti-friction bearings. Two side arms also fixed to this cross shaft carry a freely running roll over which the web is passed. This is the tension sensing roll, and in order to register the web tension a small angular lap is necessary.

The pre-set tension is obtained by a simple manual adjustment of the oil pressure applied to a synthetic rubber diaphragm in the front end of the controller. This forces the thrust pin into contact with the lever on the cross shaft, the total movement being controlled by adjustable stops. The loading pressure registers on a gauge indicating the tension for the web to be controlled.

With the web threaded through and passed over the sensing roll, the tension in the web acts against the pre-set loading of the controller, and forces the thrust pin back about 0·005 inches.

A valve in the controller will now operate a servo device fitted to the top of a standard pilot-operated relief valve, to control the oil pressure fed to an hydraulic motor driving the next section of the machine after the controller.

If, for any reason, the tension should change, the thrust pin will move, outwards indicating a decrease, inwards indicating an increase in tension, and the main oil pressure driving the hydraulic motor will immediately and automatically be adjusted to correct the tension in the web. To cater for most conditions a controller deflection of 0·005 inches is all that is necessary to bring the system under full control.

Despite the extreme sensitivity of the controller there is no tendency for tension " flutter " and the system will not " hunt ". The inherent damping of the servo device takes care of this.

At all times the actual web tension is being " measured " and all transient tension changes, which might occur for a variety of reasons, such as an overall machine speed change or a friction change in the machine itself, are automatically compensated.

Circle **47** *for further details.*

Predetermined Weight Feeders

THE predetermined weight feeders from W. & T. Avery Ltd. will handle a wide variety of materials—from whole sugar beet to very free-flowing cement.

Ingenious design has produced a simple, reliable, robust and trouble-free mechanical totalising mechanism, totally enclosed and dust-sealed within the scale headwork.

Totalised weight is shown on a 7-figure counter fitted within the indicator chart.

All machines are built into a compact, heavy gauge steel framework with a robustly built weigh conveyor mounted as a self-contained unit on the weighing system.

Weight to be delivered is set on a predetermined weight counter at the machine, or at a remote point if required. When the correct weight has been delivered, the machine will automatically stop.

Visual indication of rate of feed is provided by the scale indicator.

All three types of predetermined weight feeders can be remotely controlled, individually or in groups. All the necessary switching can be provided and required weights can be pre-set. Totalising counters can be fitted and remote indication, or recording of rate, can be provided if required. Interlocking of switching can be incorporated for installations of two or more machines.

Circle **48** *for further details.*

High Figure of Merit Pentodes

SIEMENS & HALSKE are now supplying two high performance pentodes for use in wideband amplifiers.

The E280F is a development from the E180F. The slope is 26 mA/V and input capacitance 9·3 pF. The E280F is intended for the early and intermediate stages of the amplifiers.

The E282F has a higher anode current than the E280F, and is intended for the power stages of the amplifiers. The anode current rating is 35 mA.

Both the E280F and E282F are long life types.

These pentodes are available in this country through Walmore Electronics Ltd.

Circle **49** *for further details.*

Silicon Transistors

RCA announces the 2N696 and 2N697—silicon n-p-n transistors designed for high-speed saturated switching applications in military and industrial data-processing systems.

These multi-purpose double-diffused junction transistors are specially designed and processed to assure stability of characteristics under conditions of severe thermal and mechanical stress and other environmental hazards.

The collector current rating is 500 mA.

The saturation voltages are:

$V_{CE}(sat) = 1{\cdot}5$ volts max. at $I_c = 150$ mA.

$V_{BE}(sat) = 1{\cdot}3$ volts max. at $I_c = 150$ mA.

Circle **50** *for further details.*

Printed Circuit Board Design

WITH the Electrosil " Fotoceram " method of producing prototype printed circuit boards, the time required for production is reduced to 15 minutes.

A complete kit is available which enables the designer to mark out, and etch a complete board. The kit comprises an etching tray, two grid boards, two bags of etching compound, ball-point resist " pen " and a card of masking tape. The basis of the board is a copper clad ceramic formed by the heat treatment of glass. The copper plate is virtually integral and will withstand repeated soldering (up to 50 times). Standard component mounting holes are 0·052 in. nominal on 0·1 in. centres and are through-copper-plated.

Circle **51** *for further details.*

Engine Indicator for Internal Combustion Engines

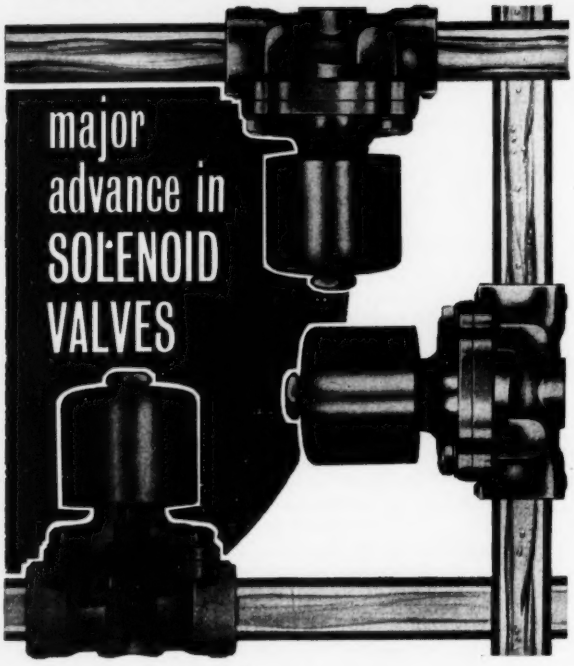
THIS instrument is of a universal nature but has been designed and developed for research in diesel engineering. It is a cathode ray indicator incorporating circuits for use with resistive, capacitive and inductive type transducers. The complete engine cycle is displayed on the screen, and measurement of cylinder pressure, injector pump needle lift and fuel line pressure can be made. Many other measurements can be made using either the standard range of transducers or any specially constructed transducer. Information on values of resistance, capacity and inductance is available.

A standard camera fitting is provided in order that a permanent recording of the indicator diagram can be obtained. Controls are reduced to a minimum to simplify operation. The indicator is completely self-contained, requiring no interconnecting between sub-units and is readily transportable.

The instrument is extensively used within the C.A.V. organisation and as a result of outside interest it is being produced on a commercial basis by Rotax Ltd.

Circle **52** *for further details.*

Circle 349 for further information



DEWRANCE

ASCO

Extra heavy industrial type construction with tight seating assured

—for manufactured and natural gas, air, propane, butane, water, petrol and light fuel oil—to 180°F.

MOUNT this new Dewrance ASCO Low Pressure Solenoid Valve in any position without affecting its operation. For pressures up to 7 psi, the Bulletin 8030A helps give full design flexibility to gas pilot applications on industrial ovens and furnaces—automatic dispensing and vacuum holding applications. This valve combines ruggedness with simplicity by housing a single moving element—the stainless steel core and composition disc—in an extra heavy forged brass body. Operation is just as remarkable. Energizing the solenoid with only 10 watts provides positive opening action. Both $\frac{3}{8}$" and $\frac{1}{2}$" pipe sizes feature oversized ports ($\frac{5}{8}$" orifice) for greater flow at an exceptionally low pressure drop. There's one source that solves virtually any solenoid valve problem—Dewrance ASCO. For full data on this new Low Pressure Solenoid Valve, write today for Application and Development Report 8030A.

DEWRANCE & COMPANY LTD.
GREAT DOVER STREET, LONDON, S.E.1
Telephone : HOP 3100 (12 lines)

Saturable Reactors

THE saturable reactors designed by Electro Methods consist of specially wound a.c. and d.c. bobbins through the centre of which pass high grade strip wound " C " cores to form a three limb construction. This assembly is embraced by aluminium alloy channel and tie rods to form a rigid structure which will withstand normal handling and can be installed in the manner of a transformer.

Terminal blocks for all electrical connections are fitted to the top channel and provided with a protective cover. Lifting eyes are fitted.

All coils are wound in high grade copper, fully cotton taped and are varnish impregnated.

If covers are required these can be offered, but the degree of protection should be specified.

Standard types are available in sizes up to 12 kVA rating and larger units can be made specially to customers' requirements.

Some variation in the maximum output voltage will occur between units, but this will never be less than 215 volts on a 240 volts supply when connected to the correct load resistance.

It will be noted that by using 3 signal windings in series a control signal of between 165—180 volts d.c. will be required. This corresponds with the output voltage normally obtainable with many mains-operated magnetic amplifiers. The fourth signal winding is then available for biasing purposes. Signal windings can of course be parallel or series connected to suit the application but it should be noted that the control current in any winding should not exceed the tabulated value by more than 50%. Where less than the total number of windings is used the control current in the remaining windings must be increased proportionally.

These " C " core saturable reactors are applicable for controlling the power in electric heaters and furnaces, and for use in automatic control schemes. Three phase loads may be handled by three single phase units.

Circle **53** *for further details.*

Oscilloscope

A NEW precision measuring oscilloscope Model 256 is now available from Kasama Electronics Ltd. The accuracy of measurements is $\pm 2\%$ on time base and Y amplifier. The Y amplifier ranges from 25 mV/cm to 100 V/cm with constant bandwidth, this being d.c. to 11 Mc/s. An internal pre-amplifier increases the sensitivity to 2·5 mV/cm with a bandwidth of 5 c/s—700 kc/s. The time base range is 0·05 μs/cm to 200 ms/cm with the aid of an X amplifier with a variable gain of $\times 1$ to $\times 10$. All e.h.t. and h.t. supplies are fully regulated. A 5 in. p.d.a. c.r.t. is used to give a large display with good brilliance. The bright-up pulse is directly coupled to the c.r.t. grid to bright-up the trace uniformly even on the slowest time base range. The price of this oscilloscope is £198 0s. 0d.

Circle **54** *for further details.*

Decade Resistor and Capacitor

DANBRIDGE have developed a precision decade resistor Type DRF wound of manganin and with wafer type switches with hard silver alloy contacts providing eight separate contact points in each position. Each

decade comprises 11 units, thus providing an overlap. The boxes are provided with from 3 to 5 decades in values from 11 × 0·1 ohms to 11 × 10,000 ohms as required.

The temperature coefficient is less than 0·002%/°C between 15 and 25°C; the thermal e.m.f. is about 1 μV/°C.

The decade condenser Type DK developed by Danbridge is manufactured in various ranges with decades from 10 × 0·001 μF to 10 × 1 μF. Different types of decade use differing types of capacitors.

Polystyrene capacitors are used for all S type decades except for the 10 × 1 μF decade in Type DK4S and are also used for the 10 × 0·001 μF and 10 × 0·01 μF decades in types with suffix A. Polyester capacitors are used for the 10 × 1 μF decades in Type DK4S. They are adjusted to 1% accuracy. Oil capacitors are used for the 10 × 0·1 μF decades in types with suffix A and also for the 10 × 1 μF decades in Type DK4A. The adjustment accuracy is 2½%. Types with suffix V are made continuously variable by the addition of a small air capacitor with a dial calibrated directly in pF. Calibration accuracy is 1%.

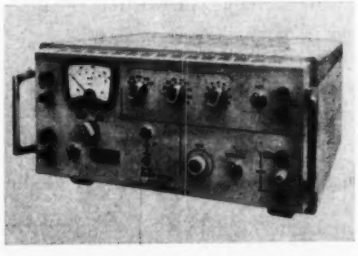
The decade, which comprises four capacitors with values 1-2-2 and 5 units, are connected as required by a four section wafer switch with ceramic insulation and silver contacts.

Both these units are marketed in this country by Metrix Instruments Ltd.

Circle **55** *for further details.*

Bench Power Supply

THE AS 1165 from Solartron is a general-purpose bench-mounting unit providing h.t., heater and bias supplies to thermionic valve circuits.



General purpose bench mounting supply unit

The unit provides two individually stabilised and electrically isolated h.t. supplies (OP1 and OP2) which may be used independently or in series. A low current output (OP3) is derived from OP2 by means of a cathode follower. Three decade switches enable OP1 voltage to be set in 1 V increments to any value between 0 and 500 V. This supply has a maximum current rating of 350 mA, and a regulation of 0·025%. OP2 provides a fixed potential of between 200 V and 250 V, as pre-selected by an internal control. The maximum available output current is dependent upon the delivered voltage and varies linearly from 100 mA at 250 V to 75 mA at 200 V, with a regulation of 0·01%. The output voltage obtainable from OP3 can be varied continuously between 0 V and (OP2−10) volt with a maximum load current of ± 3 mA. The ripple and noise component on all three supplies is approximately 1 mV peak to peak. An overload cut-out, tripping at a nominal current of 420 mA, is provided on the OP1 output, visual warning of operation being given by a panel-mounted indicator lamp. The OP1 and OP2 + OP3 supplies are independently switched, and the load currents monitored on a dual-range meter. Two independent a.c. heater voltages of 6·3 V at 5 A each are provided, and may be operated in series or in parallel. The insulation between supplies and from each supply to chassis is tested to 2,000 V. The unit will operate from 100—125 V/200—250 V, 50—60 c/s, a.c. mains input and has a power consumption of approximately 575 VA at maximum output. The instrument measures 18⅛ × 9¾ × 16½ in. The weight is 55 lb.

Circle **56** *for further details.*

Locked-ratio Frequency Multiplier

As an ancillary to their range of digital frequency meters and counters, J. Langham Thompson have available a frequency multiplier Type 702 which gives a times ten multiplication, thus permitting a corresponding reduction in count time.

The basis of the multiplier is a specially designed cathode ray tube and a ten-spoke metal target between the deflection plates and the screen. Each cycle of the incoming signal generates a circular trace and each rotation gives ten output pulses as the beam current is interrupted. Special wide range phase-shifting networks are employed to give an operating frequency range up to 100-1.

The major advantages of the system over the conventional tuned multiplier are (a) wide input frequency range (b) completely locked ratio.

These instruments are at present built to special orders. A 100/1 multiplication can be provided as an alternative to the standard 10/1 ratio.

Circle **57** *for further details.*

P-N-P and N-P-N Double Diffused Mesa Transistors

HUGHES INTERNATIONAL Series 2N1254-9, 2N1131-31A and 2N1132-32A p-n-p double diffused mesa transistors are normally supplied in TO-5 cases. Equivalent devices are also available in TO-18 and Microseal format. This series of transistors have a low collector capacitance of 10 pF. For the 2N1131 series the dissipation is 750 mW. These devices are complementary to existing n-p-n types, including 2N696-7.

Hughes 2N706-A-B, 2N753 and 2N707 Series n-p-n double diffused mesa transistors are normally supplied in TO-18 cases. Equivalent devices in Microseal format are also available. They have an output capacitance of 3·5 pF; base resistance of 15 ohms; charge storage time constant of 15 nsec; collector saturation voltage of 0·3 volts; collector-base cut-off current 20 mμA. Type 2N707 has typical maximum frequency of oscillation of 400 Mc/s.

Circle **58** *for further details.*

Miniature Tape Recorder

A PORTABLE transistorised tape recorder weighing 2½ lb is available from General Trade Equipment Ltd. Its size is 6 × 8½ × 2¾ in. It records on 3 in. standard tape at 3¾ in/s.

All controls are accessible on the front panel.
The price of the tape recorder is £15 15s. 0d.
Circle **59** *for further details.*

"Quantimeter" Continuous Container Level Indicator

THE new "Quantimeter" equipment is designed by Lancashire Dynamo Electronic Products Ltd. to provide a continuous indication of the level of stocks either at the container or, alternatively, at a remote control data recording point.

The "Quantimeter" operates on the principle of changing electrical capacitance as material builds up along the length of wire electrode installed in the container. The change in capacitance is measured within the equipment and displayed on an indicating instrument which may be calibrated in any appropriate units. A particular feature of the "Quantimeter" is the inherent compensation against indicational errors caused by variations in the moisture content of the materials. This compensation arrangement ensures that "Quantimeter" measurements are reliable even when the equipment is used on hygroscopic solids. The indication is linear from zero to maximum, and six capacitance ranges are provided to ensure that the equipment can be used in a wide variety of materials.
Circle **60** *for further details.*

Telemetry System

AVAILABILITY in this country of the Dur-O-Pulse industrial data transmission system is announced by Honeywell Controls Ltd. for straightforward or up to 24-channel multiplex transmission over long distances. It is for electricity, coal, gas, water, chemical, petroleum, steel and other industries.

Of the pulse duration type, the system uses either a 10-second or 5-second cycle-time. It simultaneously carries process measurements and control signals up to 100 miles without repeater stations by use of microwave, radio or power line carrier networks, or over a single pair of wires.

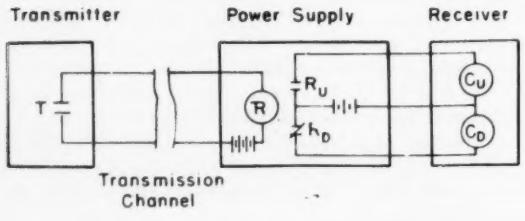
The range of the equipment varies with the number of channels and the line characteristics, but it is adequate for use with most G.P.O. rented lines, as the repeaters used with the longer lines provide virtually unlimited range.

Basically the equipment comprises a power pack, an indicator-transmitter and a recording receiver. The transmitter is a standard Honeywell indicating, controlling or recording instrument with an electronic scanning unit attached to the pointer; the receiver is a circular chart recorder. Among optional equipment are flow integrators and micro-switch or photocell alarm contacts.

The working principle is that pulses of varying duration are sent as a measure of the pressure, flow, temperature, etc., and received by the remote recording instrument containing two gear sectors to position the pen. A synchronous motor is linked to the gear sectors through electro-magnetic clutches, movement of each sector being dependent on either "pulse on" or "pulse off" time.

Accuracy of the Dur-O-Pulse system is unaffected by transmission line variations, and it is ±1% of span for 10-second scanning cycles, and ±1·3% for 5-second scanning cycles. Calibration in the field can improve these figures respectively to ±0·5% and ±0·75% exclusive of the primary element. Normal ambient temperature is assumed to be 50—120°F with 10—100% relative humidity.
Circle **61** *for further details.*

Transmitting and receiving circuitry of the Dur-O-Pulse telemetry system



Silicon Rectifiers in Insulating Sleeves

RCA's silicon diffused-junction rectifiers in the small flangeless hermetically sealed JEDEC TO-1 case with axial leads, Types 1N3193, 1N3194, 1N3195, and 1N3196, are now available with insulating sleeves. Designated 1N3253, 1N3254, 1N3255, and 1N3256, respectively, these low-cost, compact, cylindrical-design rectifiers with axial leads feature plastic, optically clear insulating sleeve with high dielectric strength—(4,500 volts/mil at 25°C, 3,150 volts/mil at 150°C).

No derating is necessary for operation at ambient temperatures up to 75°C. P.I.V. ratings are from 200 to 800 volts with forward current ratings up to 750 mA.
Circle **62** *for further details.*

High Vacuum Variable Capacitor

TYPE U240/15 is an addition to English Electric Valve Co. Ltd.'s range of high vacuum variable capacitors. The first application has been its use in the high power stages of 30 kW transmitters at the G.P.O. Radio Station at Rugby.

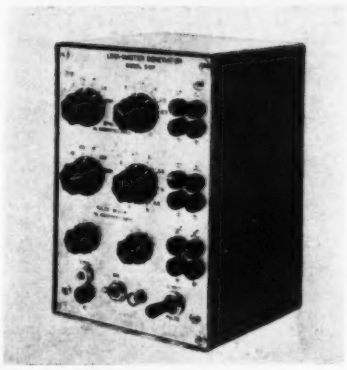
A relatively much higher reliability is confidently expected although it is smaller and lighter than the capacitor it replaces.

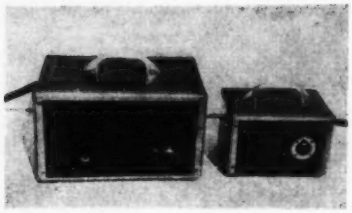
The U240/15 is designed to work at 15 kV with a linear capacity variation from 10 to 240 pF. At 30 Mc/s the maximum current rating is 50 A.
Circle **63** *for further details.*

Silicon Cartridge Rectifiers

HUGHES INTERNATIONAL'S HSC1 Series are epoxy resin encapsulated high voltage diode assemblies in a p.i.v. range 1—30 kV. The mean current is 100 mA. They are a small size, the 5 kV unit being 1·5 in. long × 0·5 in. diameter.

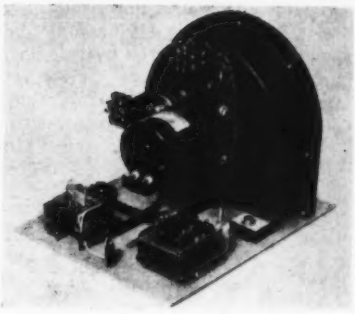
Non-standard assemblies featuring shorter length (up to 8 kV/in.), higher current rating or higher speed, are available to special order.
Circle **64** *for further details.*





Transistorised timing devices

◀*Square wave and pulse generator*



Series 5300 *integrator*

Pulse Generators

LINTRONIC LTD. have developed a general purpose programmed pulse generator which generates a train of pulses variable in its basic period, digit length, and width, with a wide selection of arbitrary patterns both at a direct pulse position and at delayed intervals. It combines an audio-oscillator and pulse generator and other logic and timing generators.

Specifications:

Pulse spacing:	8—100,000 microseconds		
Frequency range:	10—125,000 cycles		
Word length variable:	1—64 digits		
Pulse width:	1—150,000 microseconds		
Pulse selections:	Up to 24 pulses per word		
Outputs:	*Voltage*	*Impedance*	*Rise Time*
A—Combined output:	20 volts	1,000 ohms	0·5 microsecs
B—Direct output:	30 volts	6,800 ohms	0·5 microsecs
C—Delayed output:	30 volts	6,800 ohms	0·5 microsecs
Dimensions:	Standard 19 in. panel, 7 in. high, 10 in. deep		
Price:	£425 17s. 0d. ex works.		

Lintronic also have available a square wave and pulse generator in which a complete self-contained clock generates either, or both, a square wave and a pulse with frequency variable between 0·4 c/s and 500 kc/s. The pulse amplitude can be adjusted between 0 volt and −12 volts. The square wave amplitude is fixed at −12 volts. The pulse width is variable between 0·5 microseconds and 500 milliseconds. The output can be a continuous pulse or one single pulse.

Dimensions: 5 × 7 × 4½ in.

Circle **65** *for further details.*

Timing Devices

Two new fully transistorised timing devices have been developed by Portable Welders Ltd., for use with their range of maintenance and production spot welding guns.

The Mark II, with a 210/250 volt input, which is for use with the S.15 and S.20 guns, is designed to switch 30 ampere line current. Initiation is by closure of low voltage contacts in the microswitch, and the timer has an accuracy of ± one cycle with a ±10% mains variation.

The Mark IV, with a 240/415 volt input, is for use with the S.80 11 kVA and the S.120 24 kVA series production guns, and is designed to switch 100 ampere line current. Once again initiation is by closure of low voltage contacts in the microswitch, giving complete safety to the operator. The timer has an accuracy of ± one cycle or 1%, whichever is the less, independent of a mains variation of ±6%.

The time cycle of both timers is from 2—50 cycles and is determined by the discharge of current from a low loss storage capacitor into the base of a switching transistor. The duration of the current discharge is determined by a variable resistor. Both timers are fitted with sockets to take plugs on the floating 20 ft lead from the welding guns. They are designed specifically for these guns, but can be used with other equipment where accurate electronic control is required. They are priced at £28 10s. for the Mark II and £60 for the Mark IV respectively.

Circle **66** *for further details.*

Integrator, Series 5300

ELECTRO METHODS' Series 5300 integrator is a device for translating the rotations of a Series 953 integrating motor into electrical impulses which may be used to obtain a digital readout of the quantity being integrated, or for control purposes.

To convert the rotary motion of the motor into impulses a standard gearbox is fitted to the machine and the output is used to drive a shutter. This shutter, which consists of a lightweight disc with holes in it, rotates between a projector lamp and photocell to cause changes in the output of the latter when light is allowed to fall upon it. The whole shutter and light system is enclosed within an aluminium alloy casting on to which is screwed the integrating motor and gearbox to provide a rigid dust-tight assembly suitable for industrial or research purposes. This assembly is mounted on a base plate together with the electrical components for auxiliary circuits and screw type terminals for all connections. A sheet steel dust-tight case is normally provided for further protection.

The impulse rates will depend upon the motor speed (which is normally a maximum of 2,000 rev/min), the gearbox ratio and the number of holes in the shutter, and the impulse duration depends upon the size of shutter hole but will normally cover an arc of approximately 5·1°.

The exciter lamp consists of a specially designed low voltage lens ended lamp run at lower than rated voltage to prolong life and deriving its supply from a transformer mounted on the base plate. The light from the lamp is such that it will normally provide adequate output from the photocell for supply voltage

variations of +10% and −10%.

The photocell is a Ferranti M.S.1.A.E. silicon diode coupled directly to the output terminals.

Where failure of the exciter lamp could be of consequence, Electro Methods recommend a version of the integrator which is provided with twin photo-electric systems. Failure of the exciter lamp causes a relay to operate which energises a standby lamp in a second photo-electric system, the relay is provided with an additional contact, rated 3 amp (resistance) at 240 volts a.c. for alarm purposes.

The integration accuracy will depend to a large extent upon the manner in which the equipment is employed and it is possible to achieve integrations with a less than 1% error.

Circle **67** *for further details.*

Silicon High-voltage Rectifiers

TYPES CR-101 to CR-110 are a new line of high-voltage silicon rectifiers from RCA having peak inverse voltage ratings from 1,200 to 10,000 volts and average current ratings from 550 to 825 mA at 60°C. These new rectifiers consist of a series of RCA's hermetically sealed diffused-junction rectifier cells shunted by RC voltage-equalising networks, and moulded into a compact rugged case of insulating material.

The RC network parameters are chosen to provide effective voltage equalisation across the individual rectifier cells under both steady-state and transient voltage conditions. Cases have external mounting slots to eliminate the possibility of internal high-voltage breakdown, which may occur in rectifiers having mounting studs moulded into the case. Other design advantages include permanent identification markings, type number, p.i.v. rating and polarity are permanently moulded into the case.

The output current is up to 2·2 amperes for 6 rectifiers in 3-phase full-wave bridge circuit, and up to 1·65 amperes for 4 rectifiers in single-phase, full-wave bridge circuit.

The operating and storage temperature range is from 65 to 125°C.

Circle **68** *for further details.*

Fault Warning System

THE Gresham fault warning system, designed and manufactured by Gresham Automation Ltd., uses solid state techniques throughout.

The system has been specifically designed to call attention to any fault occurring in unattended vital sections of plant immediately it occurs.

It is manufactured in modules in such a way that the fault warning system is quickly and economically individually tailored to service any number of control or measurement points in any type of automated plant. It is designed to actuate audible warnings through loud-speaker amplifiers, through buzzers and also visual indication of the location of the fault either at points on the plant, or in the control room or both.

The system can also be used for indicating and, by suitable connections, recording fleeting faults which occur and correct themselves before a supervisor has had time for action.

All illuminated points are fitted with twin lamps for added reliability and may have translucent legends.

The system may be powered via a Gresham power pack or from any low voltage d.c. source such as a battery.

Low current consumption and the absence of relays and other movable contacts are added factors for the high reliability achieved.

Systems can be supplied complete with a central display panel containing all signal points and legends or as circuitry only, suitable for operating signal lamps within a diagrammatic display.

Circle **69** *for further details.*

"Microsensor" Silicon Semiconductor Strain Gauges

THE development of the flexible silicon strain gauge represents a significant advance in strain measurement techniques and conventional strain bridges with an output of, say, 20 mV can be replaced by a semiconductor bridge producing 1·3 volts (or more than five volts from a four arm active bridge), hence the cost of an amplifier can be eliminated in many applications. The marked increase in signal-to-noise ratio and low impedance permits measurements, under either static or dynamic conditions, in the sub-microstrain region, hitherto unattainable using metal gauges.

The silicon strain gauge was originally developed by Micro Systems Inc., California, for military and space applications. Subsequent research has evolved the "Microsensor" range of more than 30 types with resistance of 120 ohms up to 1,000 ohms and an active gauge length of 0·050 inches up to 0·5 inches. The maximum operating strain is over 3,000 μin/in with a transverse strain sensitivity of less than 1%. "Microsensor" gauges are available unmounted or mounted on an epoxy base carrier. In either case conventional bonding techniques are employed. The minimum radius of curvature is 0·1 inch.

The single crystal silicon elements are robust and have been used successfully in rigorous applications such as the measurement of ships' propeller shaft forces during trans-Atlantic trials, and in numerous structural strain applications in aircraft, missiles and satellites.

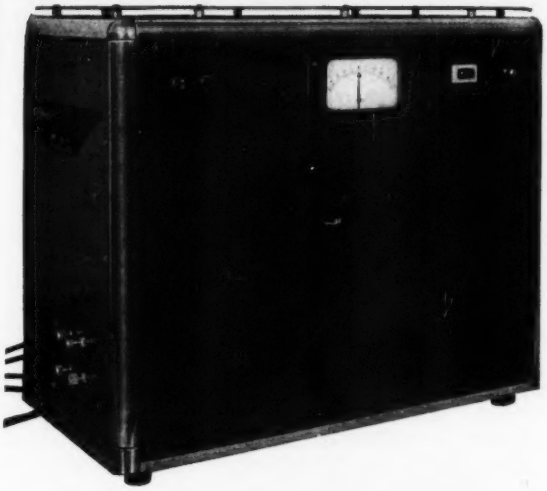
Both positive and negative gauge factors are available to provide temperature compensation. The positive gauge factor elements increase in resistance with applied strain in the same manner as conventional gauges; the negative gauge factor units decrease in resistance with strain. Since both p and n types exhibit similar temperature characteristics (increase in resistance with temperature), temperature compensation is achieved by employing the two elements in adjacent bridge arms. The latest addition to the "Microsensor" range uses a p and n type gauge on a single epoxy base carrier to form a self temperature compensated element with a gauge factor of 250 for a two arm active bridge.

A new range of pressure transducers is also available using four gauges in full bridge connection to produce 1 volt output for pressure ranges 0-50 lb/in² to 0-500 lb/in². The transducers are $\frac{1}{4}$ in. diameter and $\frac{1}{4}$ in. long with a natural frequency of 40 kc/s.

The range of "Microsensor" gauges are available in this country through Scientific Furnishings Ltd.

Circle **70** *for further details.*

Circle 350 for further information



ELECTRONIC FLAW DETECTOR

Using the eddy current principle, the Teledictor flaw detector is a versatile instrument for use in batch or automatic production of non-ferrous tubes and sections. Immediate detection of flaws can be signalled by visual or relay method, the latter enabling completely automatic sorting to be carried out.
The unit can very simply be incorporated into automatic production lines, and a comprehensive range of coils is available. Special purpose coils and sorting equipment can be made to specification, and enquiries are invited for any flaw-detection problem.

Other equipments are also available for testing ferrous material.

TELEDICTOR LIMITED

GROVELAND ROAD, TIPTON, STAFFS. Tel: 2828

Manufacturers of encapsulated coils, all types of iron-cored transformers up to 20 KVA (air cooled), solenoids, loudspeakers and specialised electronic equipment.
A Duport Company *Members of R.E.C.M.F.*

WW 63

Photo-transistor Relay

PHOTRONIC CONTROLS LTD. have perfected and can now offer their new photo-transistor relay unit designed to provide a basis for automatic control for a hundred and one industrial operations.

The equipment comprises a projector which throws a beam of light on to a receiver unit containing a photo-transistor. This is in turn connected to a control unit containing the power supplies and operational relay. With light falling on the transistor the relay will be pulled in and when the beam is broken it will drop out, providing a changeover of relay contacts to give the required control operation.

A variety of projectors and receivers are available to cater for any beam length that may be required up to 100 ft and the control circuit can be modified to provide time delays on the light beam being made or when broken. In certain circumstances different types of photo-transistor, photo-diode and photocell can be used to meet particular site conditions (e.g. humidity, dust and temperature considerations) and the particular application that the unit is required to control.

Circle **71** *for further details.*

Pressurised Container

SOLUS-SCHALL are marketing a new type of pressurised container, the Flexi-spray, to spray their Spotcheck penetrants, Zyglo fluorescent penetrants, magnetic inks and associated materials on to specimens for the detection of cracks, flaws and other defects.

The Flexi-spray consists of a power unit containing a gas propellant; a separate storage unit to contain the material to be sprayed; and a plastic moulding with valve mechanism which fits both these units.

Flexi-spray pressurised container

The Flexi-spray permits any number of materials to be sprayed in any order with one and the same power unit; solid materials in suspension can be sprayed without danger of valve blockage; materials of high viscosity can be handled efficiently; and penetrants can be purchased in bulk quantities at economic rates, the power packs being easily replaced as required.

The Flexi-spray complete costs 35/-. Replacement power packs are 7/6d. each, and additional storage units with screw tops are available from stock. A 14 oz power unit will spray about 20 fluid oz of a liquid whose viscosity is similar to that of high grade kerosene which is used with magnetic materials. This amount will decrease as the viscosity of the material used increases.

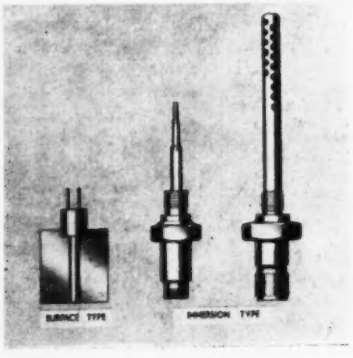
Circle **72** *for further details.*

Immersion and Surface Type Platinum Resistance Thermometers

RESEARCH AND ENGINEERING CONTROLS LTD. have developed a range of precision immersion and surface type temperature sensors, using a very pure platinum resistance wire in a strain-free condition. The sensors have a very short thermal lag, and an extreme uniformity in performance–permitting interchangeability within each standard type. The close tolerance performances more than satisfy the electrical requirements of BSG148 and the mechanical requirements of BSG100 and Av.P.24.

The miniature surface-temperature sensor, Type E130E, can be soldered, bolted or riveted to flat or curved surfaces, and is available in a range of temperature bands, a typical sensor covering −100 to +300°C: temperatures as high as 750°C can be catered for. Radiation shields can be provided, and the sensors are fully sealed against ingress of moisture. The immersion temperature sensors, types E130C, E130D, E130F, are capable of withstanding extreme thermal shocks—immersion into liquid nitrogen or heating rapidly to +750°C—without changing the measuring accuracy by more than 0·1°C at 0°C. Working pressures up to and in excess of 3,000 lb per square inch can be used, and the sensors can be supplied as small as 0·08 in. in diameter without sacrificing the performance or ruggedness.

In both types of sensor, the element has a basic resistance of 130 ohms, making them suitable for aeronautic applications in addition to their industrial uses.



High performance platinum resistance temperature sensor

A platinum resistance surface temperature sensor, the E100A, has been developed by Research and Engineering Controls Ltd., for applications where heating rates as high as 3°C per second in the range −100 to +250°C (or up to 600°C, if required) need to be known with absolute accuracy. An extremely efficient heat transfer is provided between the surface to be monitored and the platinum wire element. This element is completely strain-free, shielded to eliminate errors caused by radiation, sealed against ingress of moisture and robust to withstand the most hazardous operating conditions.

The sensor is an improvement on thermocouple devices, since it gives a higher e.m.f. output per unit temperature change—hence increasing inherent accuracy. At 0°C its resistance is 100 ohms, and with a typical current of 2·5 mA it produces an open circuit e.m.f. change in order of 100 mV per °C rise or fall. The speed of response to a unit change in temperature is less than 0·35 seconds.

Mounted on a 0·007 in. metal plate, the sensor can be seam-welded, pop-riveted, soldered or cemented to the required surface.

Circle **73** *for further details.*

"Norbit" Building Bricks

THE range of Norbit electronic sub-assemblies, designed for the speedy and simple construction of industrial control systems, has been extended by five new types: a "double Norbit" unit; medium and low power output units; a photo-head unit, and a lamp unit.

In addition, Mullard Equipment Ltd. has added a new unit to its range of power supply sub-assemblies.

"Double Norbit"—Type YL6012

The "double Norbit", which consists of two "Nor" elements built into a standard Norbit case, each element having only two inputs. The new unit is substantially cheaper than two standard Norbits and occupies only half the space.

Cross-coupling the two "Nor" elements provides a convenient method of producing a memory circuit.

Medium Power Output Unit—Type YL6008

Introduced to fill the gap between the existing low power and high power output units, the YL6008 will switch currents of up to 1·5 A at 24 V.

It is suitable for driving inductive loads, provided a catcher diode is used, and may be driven by an emitter-follower Norbit Type YL6001.

Low Power Output Unit—Type YL6009

Previously in Norbit systems, lamps and relays were driven by an appropriate output unit in conjunction with a separate emitter-follower. Now, all these functions are combined in a single unit—the YL6009—which provides a self-contained output for lamps or relays, and at the same time requires less drive.

The low power output unit incorporates a catching diode to protect the transistor from the harmful effects of back e.m.f. when an inductive load is connected. The minimum resistance of the load is 650 ohms and the supply voltage 24 V.

When used to operate a lamp the maximum lamp output current is 100 mA, thus permitting the use of a 2·4 W, 24 V lamp. In this application a surge limiting resistor should be fitted. The new unit replaces the existing relay output and lamp output units. The present emitter-follower (YL6001) will continue to be made for other applications.

Photo-head Unit YL60101 and Lamp Unit YL6011

These two units link Norbit systems to any mechanical movement which can be made to interrupt a beam of light. Strong ambient light outside the line of viewing does not affect the photo-head. The lamp unit may be placed up to eight feet away from the photo-head, and the beam can be focused to give a small section cross-over for the detection of small objects.

Both units are dust-proof and splash-proof, features

Circle 351 for further information

direct-current

TACHOMETER GENERATOR

permanent-magnet

APPLICATIONS

- **SERVOS** The highly linear output and wide speed range are ideal for velocity or integrating servos. Low driving torque permits its use as a damping or rate signal in all types of servos.
- **INDICATING TACHOMETER** Matching indicating meters available from stock in various speed ranges.
- **SPEED TRANSDUCER** Ideal for use as a speed transducer in connection with fast-response direct-writing oscillographs.

FEATURES

- **SIZE** Miniature. Approx. Dia. 1⅛".
- **OUTPUT** Various models with outputs as high as 45 volts/1000 rpm.
- **LINEARITY** Linearity from 0 to 12,000 rpm is better than 1/10 of 1% of voltage output at 3600 rpm.
- **BRUSH LIFE** Better than 100,000 hours (10 years) of continuous operation at 3600 rpm.
- **BIDIRECTIONAL OPERATION** Output in either direction is held to a ¼ of 1% tolerance.
- **RIPPLE** The rms value will not exceed 3% of the d-c value at any speed in excess of 100 rpm.
- **CONSTRUCTION** Aluminum housings with protective treatment; stainless steel shafts; fully shielded ball bearings; Mylar insulation.

SEND FOR COMPLETE DATA

TYPICAL PRICE
Model No. SA-740A-2
(7 volts/1000 rpm) **£11.**

SINGLE UNIT - POSTPAID U. K.

Quantity Discounts

Servo-Tek

PRODUCTS CO.

Main Office: 1086 Goffle Road,
Hawthorne, N. J., U. S. A.

CABLE ADDRESS: SERVOTEK HAWTHORNE, N. J., U. S. A.

which make them particularly suitable for all types of batch counting applications.

Built-in temperature compensation allows them to operate over a temperature range 0 to 50°C without adjustment.

The output from the photo-head YL60101 is compatible with the input requirements of other units in the Norbit range.

Power Supply Unit

The latest addition to the range of power supply sub-assemblies is the 6 V regulator Type YL6105.

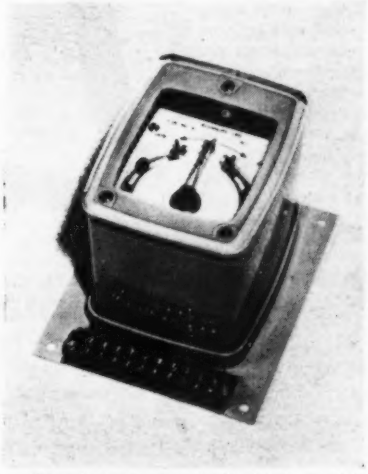
Designed primarily for use with circuit blocks (Combi-elements) it provides 100 mA at 6 V in an ambient temperature of 45°C (150 mA t_{amb} 25°C). A mains variation of +10% to −15% does not change the output voltage by more than 0·2 V, and varying the load from half load to full load to half load to no load affects the output voltage by only ±0·2 V.

Circle **74** *for further details.*

Centre Zero Moving Coil Relay

AUSTINLITE LTD. have extended their moving coil relay range with their new centre zero relay.

This achieves reliable contacting performance at low operating currents, since it incorporates a new high performance magnet system, making it possible to obtain sufficient torque when a low current is applied to give a reliable contact performance.



Centre zero moving coil relay

Fixed contacts, both high and low, are nominally adjustable to close at any pre-set point between ½ milliamp and 1½ milliamp. Development of relays operating off lower and higher currents is proceeding.

Circle **75** *for further details.*

Automatic Fuel Consumption Measuring System

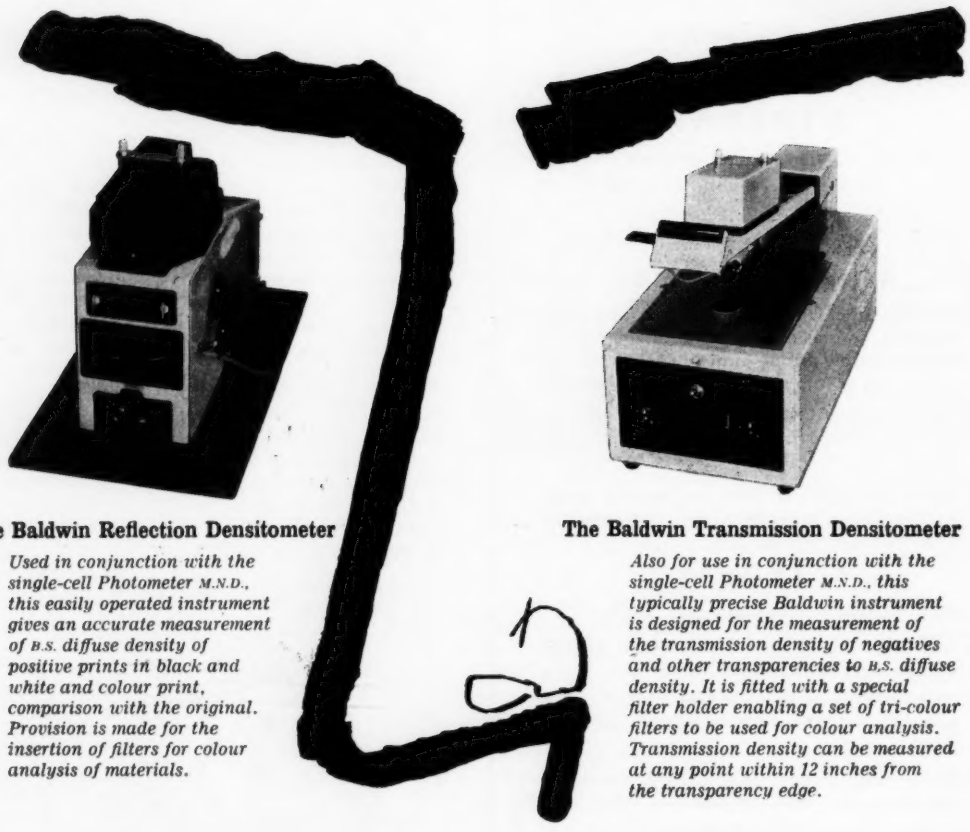
THIS equipment has been designed and developed by C.A.V. and Rotax Ltd., primarily for use in diesel engine test bays.

It provides fully automatic facilities for determining specific fuel consumption at any load.

The equipment comprises an accurate scales unit with an integral fuel balance switch to trigger a special electronic revolution counter and timing unit.

Circle **76** *for further details.*

Circle 347 for further information



The Baldwin Reflection Densitometer

Used in conjunction with the single-cell Photometer M.N.D., this easily operated instrument gives an accurate measurement of B.S. diffuse density of positive prints in black and white and colour print, comparison with the original. Provision is made for the insertion of filters for colour analysis of materials.

The Baldwin Transmission Densitometer

Also for use in conjunction with the single-cell Photometer M.N.D., this typically precise Baldwin instrument is designed for the measurement of the transmission density of negatives and other transparencies to B.S. diffuse density. It is fitted with a special filter holder enabling a set of tri-colour filters to be used for colour analysis. Transmission density can be measured at any point within 12 inches from the transparency edge.

The infallible eyes

As the techniques of commercial photography become more and more complex, the comparison between prints or negatives cannot rest on the judgment of the human eye, however well experienced. Today, the unvarying accuracy of Baldwin instrumentation is needed.

Instrument Division

PHOTOMETRY TODAY CALLS FOR BALDWIN PRECISION

Write for Brochure IP25/117 containing details of the complete Baldwin range.

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NEWS OF THE INDUSTRY

INSTRUMENTS

THE Magnetic Materials Division of the U.S. Naval Ordnance Laboratory at White Oak, Silver Spring, Maryland, have developed a new **non-magnetic alloy** named Nitinol.

Nitinol is non-magnetic, corrosion resistant, and can be hardened to 62 Rockwell "C", almost the hardness of tool steel. It is strong, and tough, having been tested up to 43 foot-pounds impact strength, as well as being suitable for use up to about 1,200°F although differing from other alloys in that its toughness increases as temperatures decrease. Its specific gravity of 6·45 offers strength without adding weight to aircraft, tools or other applications. It has a very high mechanical vibration capacity at room temperature which decreases rapidly as temperature is increased.

The development of Nitinol was generated by demands of advanced missiles and space craft for low density materials with greater strength and weight ratios and the capability of operating at very high temperatures. The first step taken by the Naval Ordnance Laboratory metallurgists was to uncover intermetallic compounds or compound-base materials with good room temperature ductility. Brittleness at room temperature has been a limiting factor in the structural use of intermetallic compounds which otherwise are highly versatile, with unusual mechanical and physical properties.

The Nitinol series consists of TiNi, a combination of titanium and nickel, and its associated phases Ti_2Ni and $TiNi_3$. The most phase pure TiNi composition was found at about 54·5% nickel by weight. This composition possessed good room temperature ductility and a moderately high melting point of about 1,300°C (2,372°F). The room temperature mechanical properties of TiNi phase indicated a ductility as high as 15% tensile elongation and up to 28 ft-lb impact strength. An ultimate tensile strength of 124,000 lb/in^2 was also measured in this composition alloy.

Magnetic susceptibility measurements over a wide temperature range showed the TiNi base materials to be paramagnetic with a permeability value approaching unity. The permeability of this class of materials was also found to be stable with variations in working and heat treatment.

THE award of a £450,000 contract for **ferrite memory systems** from Ferranti Ltd., and the recent establishment of a production unit for these systems marks the successful conclusion of a notable stage in the development of this equipment by The Plessey Co. Ltd.

Basic research into the employment of the two ferrite cores per bit technique for computer high speed storage systems was initiated by Plessey at their Roke Manor Research Laboratories in 1958.

The team at Manchester University, under Professor T. Kilburn, was also working on two cores per bit techniques as part of that university's programme for an advanced design aimed at the development of MUSE. When Ferranti joined forces with Manchester University to develop ATLAS, the first orders for memory systems were placed with Plessey.

The Plessey research team, under the direction of Dr. G. B. B. Chaplin, technical manager of the Roke Manor Laboratories, and led by Mr. W. Renwick, had to design an "Index" store with a capacity of 128 words, 25 bits and a cycle time of 0·5 microsecond and a "Working" store of 1,024 words, 50 bits with a cycle time of less than 2 microseconds.

Test results already achieved with both the "Index" and "Working" stores have shown that the fast specified cycle times have been adequately met. Throughout the design and development stages considerable attention has been given to operational reliability and safety factors so that external variation of reasonable magnitude can be tolerated. Should the units fail, however, "fail safe" arrangements are incorporated.

As a successful outcome of this comprehensive research and development programme, a Production Unit was established at West Leigh in June this year. This section is continually expanding and is now supplying a standard range of fully transistorised memory systems to British computer manufacturers.

Current research by Plessey is now being directed to techniques which will further reduce cycle time, increase storage capacity and lower operating power consumption.

Part of the main store of a Ferranti Atlas computer

PROFESSOR T. KILBURN and Dr. D. B. G. Edwards of the University of Manchester recently travelled to Moscow, at the invitation of the U.S.S.R. Academy of Sciences, to deliver a series of lectures on the **Atlas electronic computer.**

Ten lectures, over a period of five days, were given to an audience of technologists and engineers at the Institute of Precise Mechanics and Computing Technique in Moscow. Discussions showed that the Russians have a different approach to the general philosophy of computer design. In the first place, their policy is to build separate machines for scientific and data processing applications. Secondly, they are putting a great deal of effort into the development of faster storage and other components, with the intention of using this speed to achieve powerful machines of relatively simple logical design.

A major programme of work on the development and manufacture of magnetic storage devices is being conducted at the Institute itself. Professor Kilburn considered this to be on a comparable level with British technology. He felt, however, that the Russian computer scientists had the advantage of a greater measure of control over the design of these devices because of all the manufacturing processes being concentrated in the one establishment.

The British visitors learned that another scientific research establishment in Moscow was interested in the possibility of buying an Atlas computer. This confirmed an enquiry already made to the manufacturers. In fact an Atlas cannot be supplied because of a British Government trade embargo.

THE transistorised drive complex developed by Decca Radar is housed in **modules especially designed to give environment stabilisation.** The modules consist of a front door and a cold plate frame which carries the cold plates and electronic components. This frame is in turn carried on the module assembly which consists of an alloy frame with members at all corners encased in a polyester/glass moulding. There are also covers carried on this frame.

The front door provides the main insulation and mechanical protection for the front and is made up of double-faced hand laminated polyester/glass mouldings

with insulating material between them. The inner moulding is shaped to carry instruction books, etc. This front door can be removed from its hinges, which are mounted on the cold plate frame.

The cold plate frame carries the cold plates which have oilways and electric heating blankets either to take away or to supply heat, so controlling the temperature of the electronic components mounted on the boards which are carried in contact with the cold plate. Over the front of each cold plate there is an acrylic door which has slots that can be opened, through which it is possible to adjust the controls that are on the edge of each component board. It is therefore possible to adjust the equipment while the front door is open without seriously affecting the temperature control. The temperature is normally kept within $\pm\frac{1}{4}$°C.

The covers which are on the side and back are double mouldings with a polyether/arcton/isocyanate rigid foam filling to give stiffness with low weight and good insulation.

FIRTH-VICKERS STAINLESS STEELS LTD. have developed a scheme for modernising and re-organising their facilities for the **production of plates and wide sheets.**

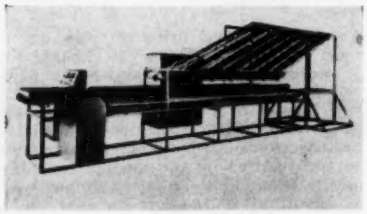
The first stage is basically the replacement of obsolete mills by a new 80 in. wide hot reversing mill with fully mechanised ancillary equipment for the production of plates up to 6 ft finished width and from 3/16 to 1 in. thickness. The mill will also be capable of rolling sheets up to 6 ft wide which will subsequently be further reduced in thickness by cold rolling.

Completion of the installation of this plant will be followed by a re-organisation of the facilities for cold rolling and final processing of wide sheets at the company's Staybrite Works, extending the handling capacity of the plant from the present 48 to 72 in. wide.

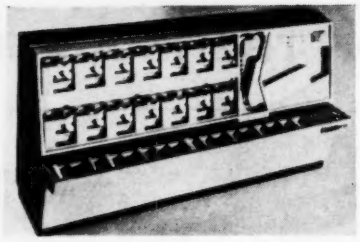
The scheme will cost in the region of £4,500,000 and take three or four years to complete, having to be carried out in stages to avoid undue interference with production.

A PROTOTYPE of an electronically controlled **automatic warehouse system** has just completed trials at the Brough factory of Blackburn Electronics Ltd. Armstrong Whitworth Equipment devised the mechanical details of the system, and Blackburns are responsible for the electronic equipment.

Blackburn automatic warehousing system



The system consists of overhead gravity-feed storage bins from which goods are fed on to a conveyor belt for transmission to a packing area. Up to five items a second can be released on to the conveyor. The gate to each bin is operated by a relay



TL 900 document reader/sorter

which is controlled by a central console. Selection of the items required to fill any given order is by means of punched cards or by manual switching. In the event of any of the storage bins becoming empty the system indicates that the item is out of stock. As the items are dispensed from the bins, an invoice is printed out stating the price, sub-totals, etc., and at completion of the order, the grand total.

A SERIES of demonstrations of the TL 900 **document reader/sorter** organised by Compagnie des Machines Bull in Paris were attended by both British and European bankers during the middle of October. The machine operates at a speed of 900 documents a minute and, for purposes of demonstration, is connected to a 300 series magnetic tape data processing system which can record, and print out, data coded in magnetic characters on the documents themselves.

HUGHES INTERNATIONAL (U.K.) LTD. have been granted type approval for their **point contact and gold bonded germanium devices.** Type approvals are CV448 for the point contact device and CV7127 for the gold bonded diode. Hughes are also able to offer a point contact device meeting CV7041 specification and a subminiature silicon power diode meeting CV7040.

ALL **microwave apparatus and components** manufactured within the Hilger & Watts Group will from 1st January, 1962, be sold under the name of Microwave Instruments Ltd., with the exception of the Microspin electronic spin resonance spectrometer, which will continue to be sold under the Hilger & Watts name.

PHILIPS ELECTRICAL LTD. have introduced a new range of **spectral lamps with transformers** and Griffin & George, appointed distributors, have developed a new stand and control gear to be used in conjunction with them.

A HUGHES INTERNATIONAL speciality is the design and manufacture of **composite diode units to customer specification.** These include bridge units, non-linear resistors and multiple Zener units, in a wide range of encapsulations.

COMPANIES

A NEW company, **G.E.C. (Engineering) Ltd.,** has been formed to take over and develop the engineering activities of The General Electric Co. Ltd. This is in accordance with the new policy of the G.E.C. to form its manufacturing groups into subsidiary companies.

The manufacturing resources of the new company comprise the Electrical Engineering Works at Witton, Birmingham, and the Mechanical Engineering Works at Erith, Kent.

The following appointments have been made to the board:

Mr. R. N. Millar, chairman and managing director; Mr. T. H. Kelsey, director and general manager (Witton Works); Dr. K. J. Wooton, director and general manager (Erith Works); Mr. C. J. O. Garrard, commercial director; Mr. E. Nicholson, financial director; Dr. H. K. Cameron, development director; Mr. G. M. F. Donnelly, production director; Mr. W. D. Morton, personnel director (and assistant general manager, Witton Works); and Mr. J. E. Thomas, secretary.

Two further appointments of importance to the new company are Mr. D. W. T. Angwin, who now becomes assistant general manager, Erith Works; and Mr. J. C. Morris, who becomes commercial manager, Export Projects. Both these appointments are effective from 1st January, 1962.

Two further new operating companies, **G.E.C. (Telecommunications) Ltd.** and **G.E.C. (Electronics) Ltd.,** have been formed by The General Electric Co. Ltd., to take over the activities of the company's Telecommunications Group.

Co-ordination and direction of these copmanies will be undertaken by a newly formed holding company, **G.E.C. (T & E) Holdings Ltd.** The holding company will also be responsible for co-ordinating and directing the activities of the following subsidiary companies: The M-O Valve Co. Ltd., Salford Electrical Instruments Ltd., Watson & Sons (Electro-Medical) Ltd., Machlett X-Ray Tubes (Great Britain) Ltd., and of the G.E.C. Semiconductor Division.

Mr. O. W. Humphreys has been appointed executive chairman of the holding company and chairman of the two new operating companies. Mr. W. A. C. Maskell has been appointed director of the holding company. Mr. C. Riley and Mr. R. J. Clayton have been appointed directors and general managers of G.E.C. (Telecommunications) Ltd. and G.E.C. (Electronics) Ltd., respectively.

The headquarters of G.E.C. (Telecommunications) Ltd. will be at G.E.C. Telephone Works, Coventry, and of G.E.C. (Electronics) Ltd. at Union Works, Wembley. The main production units of G.E.C. (Electronics) Ltd., will be at Spon Street and Ford Street, Coventry; Broad Oak, Portsmouth, and Union Works Wembley.

THE official opening of the new **Ferranti electronics laboratory** at Silverknowes, Edinburgh, was performed on 12th October by Sir Vincent Z. de Ferranti, M.C., LL.D., M.I.E.E., chairman of the company, Mr. Sebastian Z. de Ferranti, managing director, and other members of the board of directors of Ferranti Ltd.

The new laboratory, which has cost the company £175,000 to build and will employ about 200 people, houses the applied electronics department under the

management of Mr. J. Stewart, M.A., B.Sc., M.I.E.E.

The department is employed principally in the development of radar and other systems for the services for both airborne and ground use, but a variety of non-military projects are also being undertaken which will benefit many of the major industries in this country. This work involves the theoretical study and practical application of the generation, transmission and reception of frequencies from only a few cycles per second to tens of thousands of millions per second.

Hawker Siddeley Aviation have re-organised their **Astronautics Group** and placed it under the direction of Mr. G. K. C. Pardoe, of the de Havilland Aircraft Co. Ltd. The team will be led by Mr. Geoffrey Coates, who is being transferred to de Havilland's from the Hawker Siddeley Advanced Projects Group.

Astronautics is now passing from the purely theoretical phase into one in which the practical engineering problems will form an increasingly large part of the programme. This re-organisation will enable the practical background of a guided weapons team to augment the facilities at the disposal of the Astronautics Group, and will also continue to give active support to the aims and objectives of the British Space Development Co.

Two American scientists, Dr. F. C. Werner and Mr. T. Lode, president and vice-president/technical director respectively of the Rosemount Engineering Co., recently visited **Research and Engineering Controls Ltd.** The purpose of their visit was to discuss the research and development programme that the English company is undertaking on behalf of the American company.

During their stay the scientists visited French, Swedish and German aeronautical companies with Mr. B. Rogal, B.Sc.(Eng.), A.I.M.E.E., managing director of Research and Engineering Controls Ltd., to analyse the markets and to promote sales of the precision products now being marketed in the U.K. and the U.S.A. Research and Engineering Controls Ltd., although only a newly formed company, have already developed a wide range of precision components, in particular a series of highly accurate resistance sensors.

STANDARD KOLLSMAN INDUSTRIES INC. of Illinois have established, in this country, a British subsidiary under the name of **Kollsman Instrument Ltd.,** to handle their range of precision electronic and electrical products for industry, defence and the consumer.

Mr. A. A. Brown and Mr. F. G. Thouard have been appointed managing and deputy managing directors respectively of Kollsman Instrument Ltd.

AT the beginning of November a management meeting was held in New York between **Kollsman Instrument Corporation** and **Smiths Aviation Division** of S. Smith & Sons (England) Ltd.

Mr. Leonard A. Morgan, divisional director and general manager of Smiths Aviation Division, and Mr. David B. Michinson, president of Kollsman Instrument Corporation, jointly announced that all orders for Kollsman products presently in the hands of Kelvin & Hughes Ltd. and/or Smiths Aviation Division will be filled and serviced by those organisations.

The fulfilment of future orders for Kollsman products will be the responsibility of Kollsman Instrument Ltd.

ON a recent visit to **E. K. Cole Ltd.,** following the resignation of Mr. E. K. Cole, C.B.E., from the deputy chairmanship of British Electronic Industries and the chairmanship of E. K. Cole, Ltd., Mr. C. O. Stanley, C.B.E., chairman of B.E.I., addressed the employees after discussions with directors. In his speech he stated that one of the Pye main television set factories had been re-organised to carry out the manufacture of communication equipment in order to transfer some of the load to Southend, and that the company were improving in every way their competitive power.

JOHNSON, MATTHEY & CO. LTD. have acquired the majority of the shares of the Belgian precious metal company, Pauwels Frères S.A., who for the past thirty years have acted as their principal agency in Belgium.

The future name of the Belgian company will be **Johnson, Matthey & Pauwels S.A.** Mr. H. Limbourg, formerly general manager, becomes managing director and Mr. L. Mendel has been appointed general manager, while Mr. R. Turner and Mr. P. G. Smyrk (directors of Johnson, Matthey) join the board of the Belgian company.

Elliott Automation Ltd. have formed a new subsidiary company, **E-A Space and Advanced Military Systems Ltd.** It is planned that the new company will play a large part in promoting British military and space systems for European and other foreign countries.

DUE to the congested working conditions at Ealing and Uxbridge, **Arrow Electric Switches Ltd.** have opened a new 200,000 sq ft plant at Brent Road, Southall, Middlesex. To mark the occasion over 250 customers, suppliers and others long associated with the company, together with local dignitaries and Members of Parliament, were invited to a reception and cocktail party in the works.

Vickers-Armstrongs (Aircraft) Ltd. have formed a **Systems Division** which will be responsible for all electric, electronic and integrated control and navigation systems design.

The new division is headed by Mr. H. Zeffert, A.E.R.Ae.S., A.M.I.Mech.E., Mem.A.I.E.E., as chief systems engineer/E, with Mr M. H. Still as his deputy.

WITH the first stage of the merger between Sir W. G. Armstrong Whitworth Aircraft Ltd. and Gloster Aircraft Co. Ltd. completed, the Gloster Aircraft Co. has now ceased trading under that name and all the business of the two companies is now being conducted under the name of **Whitworth Gloster Aircraft Ltd.**

A NEW company under the name of **Experitron** has been formed by two young Sheffield electronics engineers, Mr. Harold Higginbottom and Mr. David Outram, at 165 Young Street, Sheffield, 1. Their aim is to investigate any control or power problems arising in any industry, develop new components and circuits, and build prototypes of any sort of equipment, including electronics, special power units, photo-electrics and audio equipment.

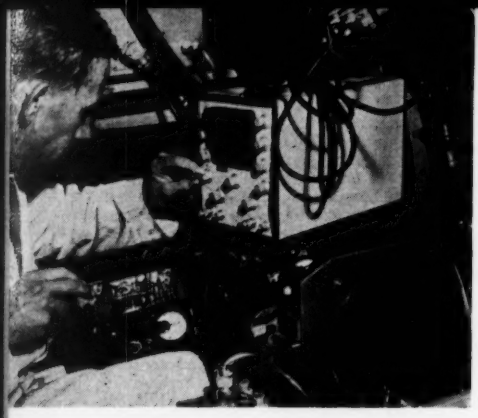
Painton & Co. Ltd., the Northampton electronic component designers and manufacturers, have recently released details of a half a million development scheme which will provide additional manufacturing and office space on an eight acre site adjoining their existing factory.

Apart from an extensive range of plugs and sockets, fixed resistors and high quality switches, Paintons hold the sole manufacturing rights for Europe, Africa and Australasia of the Bourns Trimpot subminiature potentiometers.

These "missile-quality" potentiometers have made necessary an extensive quality control department together with an inspection organisation able to provide a 100% inspection at eleven different stages of manufacture.

"Monitor" Patent Safety Devices Ltd. have made arrangements to merge with **D.P. Controls Ltd.** and Newcastle Engineers Ltd., under the overall direction of Mr. G. V. Carr, following the retirement of "Monitor's" 80 years old founder, Mr. C. L. Stokoe, M.I.Mar.E., Mech.E.

Part of the manually operated switch assembly bay at Arrow Electric Switches Ltd.



The portable Microcell Type 400 transistorscope being used to test airborne equipment in a Bristol 192 helicopter at the Weston-super-Mare base of the Bristol Helicopter Division. The transistorscope Type 400, which weighs only 13 lb, and being battery operated is independent of mains supply, has been developed by the Electronics Division of Microcell Ltd.

A NEW company, **Shipton Automation (Sales) Ltd.,** has been formed, responsible for all marketing activities of E. Shipton & Co. Ltd., R.F. Electronics Developments Ltd., and English Telephone Co. Ltd.

Directors are listed as Messrs. C. Will (managing), V. Younger, F. Jasper, L. Davis and O. Egert.

Square D Ltd. have started building a new factory at Cheney Manor, Swindon, Wilts. Completion of the new building is scheduled for mid-1962.

Techne (Cambridge) Ltd. have opened a subsidiary company on U.S. Route 1, Princeton, New Jersey.

AGENTS

Walmore Electronics Ltd. have been appointed United Kingdom representatives for the special electronic valves manufactured by Siemens & Halske A.G., of West Germany. Among the range of electronic valves now available in this country are long life and rugged receiving valves for industrial applications, high figure of merit tetrodes, pentodes and double triodes, ceramic triodes for use up to 9,000 Mc/s and transmitting triodes and tetrodes.

George Cohen Sons & Co. Ltd. have been appointed sole selling agents in the U.K. for all measuring equipment of Czechoslovakian manufacture exported to this country. This range of equipment will include Supraphon surface roughness specimens, portable and bench type hardness testers, an optical clinometer, optical dividing head, profile projector, comparison and inspection microscopes and an electro-magnetic measuring and checking device.

THE Special Products Division of Thorn Electrical Industries Ltd. have appointed Messrs. **Hardman & Co.,** of Baillie Street, Rochdale, Lancs., as stockists and distributors for their range of electrical components and relays in North West England.

R. H. Cole (Overseas) Ltd. are now sole U.K. agents for the range of tape heads manufactured by Wolfgang Bogen G.m.b.H. The components include mono and stereo heads for domestic tape recorders, erase heads and a range of single and multiple heads for professional applications.

CONTRACTS

THE Royal Air Force have placed with **Honeywell Controls Ltd.** a number of orders for their systems analysers for use with the English Electric Lightning. This analyser represents the latest development in a long line of similar equipment produced by Honeywell and embodies many years of actual service experience.

The analyser performs one test per second. Electronic systems are checked individually and in combination with each other. The total test time is speeded up by scheduling tests in an orderly but instantaneous routine.

DURING the Electronic Computer Exhibition, **The English Electric Co.** received firm orders worth about £1m. from the Universities of Birmingham, Glasgow, Leeds and Liverpool for the English Electric KDF9 high speed data processing system. Each of these universities is to install a comprehensive KDF9 system—the new all-British computer designed and built by English Electric—and will use it for research, the training of students and some university administrative work.

Henry Simon have a contract to install sugar handling plant at the Liverpool biscuit works of William Crawford & Sons Ltd. The purpose of the plant is to bulk store granulated sugar, grind it when required and convey weighed batches pneumatically in either a ground or granulated state to the factory mixing service bins.

The compressors supplying air for the bulk pneumatic conveying lines will also be used for the bulk sugar conveying lines. This is made possible by the use of Simon sonic valves which enable a number of blowing lines to be fed at a constant predetermined pressure from a single compressor. The grinding and batch distributing system will operate under automatic control, weight selection being achieved by a modified version of the Simon Select-O-Weigh automatic proportioning system.

AGREEMENT

J. Langham Thompson have concluded an exclusive licence agreement with **Hastings-Raydist Inc.,** Hampton, Virginia, U.S.A., under which J.L.T. will market and subsequently manufacture the full range of Hastings-Raydist vacuum gauges, altimeters, air velocity instruments, flow meters, mass flow meters, electroverters, thermal conductivity gauges, etc. Initially J.L.T. will stock vacuum gauges and first supplies will be available shortly.

The Telegraph Condenser Co. Ltd. and the **Sprague Electric Co.** of America have reached an agreement whereby they are to combine their research and manufacturing experience. The Telegraph Condenser Co. Ltd. are the sole distributors in the United Kingdom for the Sprague range of products.

EXPORT

DURING the Electronic Computer and Business Efficiency Exhibitions substantial orders were placed for **I.C.T.** computers and punched card equipment from several overseas countries.

Orders for the I.C.T. 1301 computer include one from Singapore City Council valued at more than £70,000 and one from Electronic Data Processing Ltd., a data processing service organisation recently established in New Zealand.

The Central and National Bank of Egypt have ordered some £100,000 worth of punched card data processing equipment and a further order for 80 column punched card equipment has been received from the Egyptian Government.

A manufacturing company in Mainz, Werner und Mertz, have ordered an I.C.T. 1202 computer for invoicing and related accounting procedures.

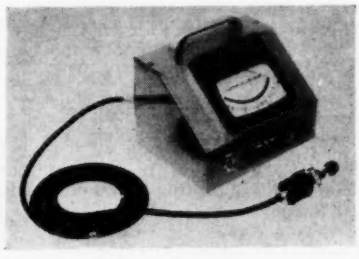
The number of I.C.T. punched card users in Eire was augmented by two orders placed by John Fisk & Sons and the Arklow Pottery Co. of Dublin. Because of intense continental interest in the 558, I.C.T.'s new electronic computer for 40 column punched card users, the prototype on show at the Business Efficiency Exhibition was flown to Paris for the Office Equipment Exhibition.

THE **Overseas Marketing Service** of Sales Audits Ltd., are to provide a new service which will aid exports. Any British manufacturer who wants to sell in Europe can now obtain details of what marketing and sales policy to adopt, what prices to charge and who the most suitable distributors, wholesalers and retailers are, etc.

Manufacturers can commission a survey for their products in any one of the countries in the Six or Seven and within a few months in almost any country.

EIGHT electronically controlled **Robotug driverless tractors** have been installed

Hastings-Raydist vacuum gauge



by E.M.I. Electronics Ltd. for Danzas Transport, at a new goods station in Paris, to speed handling between railway trains and road vehicles.

The installation is arranged to allow the transport of goods to and from a dispersal area, and is used in conjunction with all kinds of road transport as well as the goods trains at the five platforms involved.

The system, which was installed by a mixed team of English supervising engineers and French labour, is equipped with the latest monitoring devices and provision has been included for all the tugs to return automatically to a pre-set control point.

Dartronic Ltd. are appointing agents in several countries to market a low-price general-purpose oscilloscope.

Selling in the United Kingdom at £36, it is claimed to have many applications in industry and research, and radio and TV servicing. Its cathode ray tube is enclosed in a shield for protection against spurious deflection from stray magnetic fields and the complete instrument, which is portable, is housed in a metal cabinet with a two tone finish.

Solartron have sent their group field sales manager, Mr. T. Morrison, to Japan, he left by air on 7th November.

He is due to operate with the Kyokuto Boeki Kuishu organisation until 15th December, this organisation were appointed exclusive agents for Solartron products in Japan in June of this year.

" Jock " Morrison will lend all assistance to Kyokuto Boeki Kuishu in launching their sales drive in Japan, drawing upon the experience he has accumulated with Solartron in America and U.K. since he joined the company in 1954.

THE responsibility for export sales of equipment manufactured by **Cawkell Research & Electronics Ltd.** has been assumed by **Dawe Instruments Ltd.**, following the entry of both firms into the Simms Group. The production of Cawkell equipment has already been integrated with that of Dawe at their Western Avenue factory.

E.M.I. Electronics Ltd. have received an order for two E.M.I. vidicon camera channels from Polskie Radio of Poland following the demonstration of this equipment in Warsaw earlier this year. These channels comprise camera, camera control unit, remote control panel and four position lens turret.

Elliott Brothers (London) Ltd. are to supply radar, computing and control equipment for prototypes of 30 mm light anti-aircraft gun mountings which the Federal German Republic has ordered from the Hispano Suiza Co. of Switzerland.

SERVICES

Ina Needle Bearings, of Llanelly, manufacturers of cage guided needle bearings, needle thrust bearings and cam followers, have opened new premises at 232 Tolworth Rise South, Surbiton, Surrey, in order to provide free technical service, including assistance on design and advice on production problems, in the London area.

The London office will be under the management of Mr. D. G. Galpin, who, together with two colleagues, is responsible for serving the London area and South and South West England.

A technical advisory service is also available to customers in the Midlands (Mr. A. T. Davis, 41 Morven Road, Sutton Coldfield, Birmingham), East Midlands (Mr. K. F. Webb, 9 Kilburn Avenue, Oadby, Leicester), North and North West (Mr. W. Mason, 9 Tredgold Crescent, Bramhope, Nr. Leeds) and Scotland (Mr. J. P. Heron, 126 Netherlee Road, Braehead, Cathcart, Glasgow).

Electronic Associates Ltd. are operating a rental plan for all EAL-manufactured equipment that sells for £1,600 or more. This includes the TR-10 transistorised desk-top size general purpose analogue computer, the large scale 231R and 221R general purpose analogue computers, digital plotting systems and digital voltmeters. Computers, computer systems and digital plotters can be rented for a minimum of one year periods, and all other equipment can be rented for three, four or five year periods. The rental plan replaces the former lease plan which included only large scale computers.

EDUCATION

THE first **Course in Applied Pneumatics,** sponsored by the *Journal of Applied Pneumatics,* the house journal of Martonair Ltd., was held from 2nd—6th October.

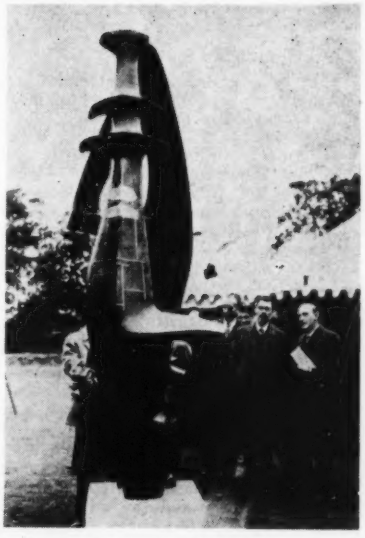
The course was attended by twenty students from all parts of the country and the subjects covered by the lectures included compressed air theory, circuit design, mechanism and machine design, equipment design, maintenance and hydro-pneumatics. A works visit and practical sessions were also included.

Further courses are being held on 5th and 26th March, 1962, and vacancies exist on a course commencing on 16th April, 1962.

THE Northampton College of Advanced Technology have arranged a series of courses under the heading of **" Direction and supervision of scientific and engineering personnel ".** The course is intended for senior managers who will already have had practical experience in the field of study. To enable students to relate this experience to basic theory, the course will include some work in the field of psychology and sociology. The courses which are now in progress until 6th June, 1962, consist of twelve full days at fortnightly intervals.

A FURTHER **"Introduction to Industry"** training course will be held from 8th—12th January, 1962, at the Chippenham Works of Westinghouse Brake & Signal Co. Ltd.

The course, designed for sixth form students taking G.C.E. "A" level examinations in scientific subjects in 1963, gives an insight into the engineering industry, how it works, the training facilities and career prospects.



This winning entry of Mullard's sculpture competition was unveiled by the managing director, Mr. S. S. Eriks, K.B.E., at the Mullard Research Laboratories recently. The sculpture " Polar Theme " is by Keith Godwin, A.R.C.A., R.B.A., and has as its theme the fact that opposite poles attract and like poles repel.

ASSOCIATIONS

THE Council of the **British Institution of Radio Engineers** has awarded seven Premiums and Awards to authors of outstanding papers published in the Institution's Journal during 1960:

The premier award, the Clerk Maxwell Premium, which is for the most outstanding paper published in the Journal during the year, has been awarded to Dr. G. T. Wright, of the Electrical Engineering Department of the University of Birmingham, for his paper on " A Proposed Space-Charge-Limited Dielectric Triode ".

The Heinrich Hertz Premium for the outstanding paper on mathematical and physical aspects of radio and electronics has been awarded to Mr. R. A. Waldron, M.A. (Associate Member), of Marconi's Wireless Telegraph Co., author of the paper " Features of Cylindrical Waveguides Containing Gyromagnetic Media"

The recipient of the **A. F. Bulgin** Premium for the outstanding paper on measurements in radio and electronics is Dr. A. Kraus, an engineer with the German firm of Rohde and Schwarz, Munich, for his paper " Reflection Coefficient Curves of Compensated Discontinuities on Coaxial Lines and the Determination of the Optimum Dimensions ".

The first award is made this year of the Arthur Gay Premium for the outstanding paper on production techniques in the radio and electronics industry. It is being awarded to Mr. E. Davies, who is with Marconi's Wireless Telegraph Co., for his

paper "The Application of Printed Wiring to Development and Small Batch Production with particular Reference to Television Equipment".

The Leslie McMichael Premium for the outstanding paper on radio communication is awarded to Mr. C. H. Dix, B.Sc., and Mr. W. E. Willshaw, M.B.E., M.Sc. Tech., of the Hirst Research Centre, for their joint paper on "Microwave Valves: A Survey of Evolution, Principles of Operation and Basic Characteristics".

The Lord Rutherford Award for the outstanding paper on electronics associated with atomic physics was made for the first time this year and was presented to Mr. E. C. Fellows (Associate Member), of the A.E.I. Research Laboratories at Aldermaston, for his paper on "Energy Stabilisation of a 4-MeV Electrostatic Accelerator using Controlled Corona Discharge".

The Charles Babbage Award has been won by Mr. E. M. Bradley, B.Sc., of International Computers and Tabulators, for his paper "A Computer Storage Matrix Using Ferromagnetic Thin Films".

The Premiums and Awards will be presented by the President of the Institution at a special general meeting to be held in London on Wednesday, 24th January.

THE **Society of Environmental Engineers** has now entered into its third year, with a membership approaching the 250 mark, of whom ten are sponsor members. Colonel F. I. L. Knowles, of the Armament Research and Development Establishment, is to be this year's chairman. The aims of the society are to provide a forum for discussion of problems and the latest techniques in environmental testing, such as vibration, shock, noise, climatic, dust, corrosion and other environments, and to organise visits, symposia and exhibitions in this field.

Branch meetings in different parts of the country and visits to equipment manufacturers and test facilities have been arranged. The volumes for 1959/60 and 1960/61 annual proceedings of the society are now available at a cost of 25/- each. Further details and membership application forms can be obtained from the Hon. Secretary, Suite 7, 167 Victoria Street, London, S.W.1.

A SERIES of meetings organised by the **International Electrotechnical Commission** took place during the middle two weeks of November, and was attended by nearly 200 representatives from 16 countries.

The theme of the meeting was world standards agreement on electronic components, equipment and procedures, including the electronic aspect of computers and data processing machines.

Among the topics discussed by the delegates were world standards for:

1. Sockets and accessories for electronic tubes and valves
2. Electromechanical components for electrical equipment
3. Environmental testing procedure for electronic components and equipment
4. Printed wiring
5. Computers and data processing.

PARTLY in conjunction with the **Institute of Service Management,** investigations are being made as to the possibility of producing a monthly magazine on a national trade basis to cover all aspects of service management. The contents will consist of technical and semi-technical articles, together with news items relating to new equipment, systems and procedures. Further details are available from A. J. Miller, of 24 Central Buildings, Southwark Street, London, S.E.1.

VISITS

THE **N.A.T.O. Special Working Group** on synchros and servomotors visited the Beckenham factory of Muirhead & Co. Ltd. during November, the first of a series of tours they are making to British synchro manufacturers.

THE first of a series of **Polish technical trade delegations** have just spent fourteen days in the United Kingdom at the joint invitation of The London Chamber of Commerce and The Federation of British Industries.

Among the members of the delegation were Mr. Bolesaw Baranski, deputy director, Board of Precision Instruments, an expert in roller bearings, and Mr. Janusz Matejak, director, Industrial Automatics Plant, an expert in industrial automation. Some of the firms concerned with instrumentation visited by the delegation were de Havilland Aircraft Co. Ltd., Foster Instrument Co. Ltd., Foxboro-Yoxall, George Kent Ltd., Elliott Automation, Solartron, Castrol Ltd., Newall Group Sales Ltd., Coventry Gauge & Tool Co., and Automatic Control Engineering.

RESEARCH

A NEW form of crystal growth of silicon which may have important implications for semiconductor devices has been reported by Bell Telephones Laboratories. Bell scientists have succeeded in growing from the vapour **ribbons of silicon** which are so thin they are semi-transparent. The ribbons, typically about one micron thick, are near-perfect crystals. In the process for making silicon ribbons, silicon is reacted with iodine and hydrogen, together with small amounts of arsenic and nickel, at high temperatures in a closed tube. The ribbons, together with silicon whiskers of an hexagonal cross-section, grow rapidly in the hot tube. The ribbons vary from 0·1 to 15 microns in thickness, are about 0·1 millimetre wide, and from one to three centimetres long. They contain few or no crystal defects except for a single twin plane parallel to the ribbon surface. Because of their crystalline perfection, the ribbons are very strong mechanically. They are also quite flexible due to their extreme thinness.

The existence of a single twin plane in all the ribbons observed is a central feature of a theory which explains some of the main mechanisms of ribbon growth. According to the theory, the twin plane, plus what appears to be a growth poisoning effect of certain impurities, cause the crystal ribbon to grow very rapidly in length but relatively slowly in width and thickness.

The ribbons are quite uniform in thickness and width, and have a nearly perfect surface. These properties would make it possible to incorporate them directly into semiconductor devices with little or no mechanical preparation. The Bell scientists emphasised that considerable development would be required before the ribbon process could be used in commercial devices. With the achievement of control of impurities at desired levels, a number of potential applications can be envisaged. Use of the ribbons for piezoresistive strain gauge applications appears promising because, being extremely thin and flexible, they can accurately follow elastic strains in materials to which they are bonded.

Mr. Tsutsumi (centre) chief mechanical engineer of the Annaka Seiki Co. Ltd., of Tokyo, on a recent visit to E.M.I. Electronics Ltd., where he was shown the company's latest electronic machine tool control systems and electronic computers

A MOCK-UP was shown at the recent American Rocket Society Exhibition in New York of the 9½ × 6½ ft model of the **Orbiting Astronomical Observatory.** This project will lead to the production of two 3,300 lb flight models under the terms of a $30 million NASA contract. The Orbiting Astronomical Observatory will monitor ultra-violet, infra-red and X-rays from stars. It will consist of a standard shell containing stabilisation power and telemetry instruments, into which one or more separate experiments can be fitted for each flight. Paddles covered with solar cells will generate the 350 watts of power required to operate the experiments and satellite equipment. The satellite's stabilising system will "lock" astronomical equipment on the star, sun or planet it is observing. Using its fine point control, it will be able to track a star with an accuracy of one-tenth of a second of arc.

EXHIBITIONS CONFERENCES, ETC.

AT the **Optical Maser Symposium** held at Bell Telephone Laboratories, New York, on 10th October, one of the subjects discussed was devoted to neodymium in calcium tungstate, a new material for solid state masers. The potentialities of this material were revealed by the discovery of a strong infra-red fluorescence. With crystals pulled from the melt an optical maser was constructed that operates at room temperature with as little as five joules of input power. The

emission line is in the desirable (photographable) part of the infra-red region, 10 600 Å. Research on this material has been carried out by Dr. L. F. Johnson and Dr. K. Nassau, of Bell Telephones.

Taylor, Taylor & Hobson and Société Génévoise Ltd. recently held a joint private exhibition of their precision measuring equipment. The new "Trioptic" three co-ordinate universal measuring machine was shown by the Société Génévoise as well as their range of universal measuring machines and accessories. Taylor, Taylor & Hobson showed a range of their machine tools and examples of the Talyrond, Talyvel, Talysurf and Talymin equipment.

NEW ADDRESSES

Amphenol-Borg Ltd., Amphenol Electronics Division, Thanet Way, Tankerton, Whitstable, Kent. Tel: Whitstable 4345.

Friden Ltd., Friden House, 93-101 Blackfriars Road, London, S.E.1.

The General Electric Co. Ltd., Commercial and Administrative Departments, Semiconductor Division, Broadstone Works, Broadstone Road, Reddish, Stockport, Cheshire. Tel.: Heaton Moor 6351/60.

The General Electric Co. Ltd., Installation Equipment Group, Export Division, Horsenden Lane South, Perivale, Greenford, Middlesex. Tel.: Alperton 2831.

Hygrotherm Engineering Ltd., Empire House, 414 Chiswick High Road, London, W.1.

Levell Electronics Ltd., The Trading Estate, Park Road, Barnet, Herts. (Telephone number remains the same).

Microwave Instruments Ltd., Sales Office, 98 St. Pancras Way, London, N.W.1.

Polypenco Ltd., Gate House, Frethern Road, Welwyn Garden City, Herts. (Telephone number remains the same).

Research and Engineering Controls Ltd., South Bersted Industrial Estate (Orchard Way), Bognor Regis, Sussex.

The telephone number of **Hellermann Ltd.** and **Bowthorpe Electric Co. Ltd.** has been changed to Crawley 28888.

MANUFACTURERS' LITERATURE

UK-AN Connectors

Publication No. 109/1 from the Plessey Co. Ltd. gives comprehensive details of the aluminium range and the steel range of UK-AN connectors. This revised and enlarged brochure contains full technical and physical details together with information on wiring procedures and the necessary tools. Supplementary information covers the design and electrical features of these connectors together with the use of hermetically sealed (glass-sealed) connectors.

Circle **77** *for further details.*

Dye-dilution Recorder

The completely redesigned Cambridge dye-dilution recorder, Mark II, for detecting and diagnosing structural and functional disorders of the heart is the subject of List 326/2 from Cambridge Instrument Co. Ltd.

The technique of dye-dilution curve recording is used for investigating intracardiac shunts and valvular regurgitation, and for determining cardiac output and central blood volume. A technical specification is given.

Circle **78** *for further details.*

"Silicones in Engineering"

"Silicones in Engineering" is the title of a new 24-page fully illustrated booklet available from Midland Silicones Ltd. This booklet sets out the principal ways in which silicones can be used in engineering and allied industries, with examples and illustrations from current industrial practice. Among the uses classified under silicones for electrical insulation are silicone-insulated dry-tape transformers, silicone-insulated motors and silicone insulating compound MS4 and under silicone fluids, high temperature oil baths.

Circle **79** *for further details.*

Narda Catalogue

Aveley Electric Ltd. have available in this country the new Narda 132-page catalogue covering the microwave and u.h.f. range of electronic test equipment. There is also a section devoted to measurements and technical data and several microwave component quick reference charts.

Circle **80** *for further details.*

"News from Londex"

The August issue of *News from Londex* contains details of the company's activities and developments in the field of automatic electrical control.

Circle **81** *for further details.*

Metering Pumps

Publication No. S/270 describes the G.50 proportioning pump manufactured by E.C.D. Ltd., one of the Wallace & Tiernan Group of Companies. This pump has been designed to embody a high degree of flexibility in layout, together with a wide range of metering capacities and operating pressures. It also incorporates a unique stroke adjustment mechanism, states the company, which allows variation of pumping capacity manually, remotely or automatically, while the pump is running.

Twenty-four typical pump arrangements are illustrated on the back page of the leaflet.

Circle **82** *for further details.*

Control Cabinets

Photo-electric control cabinets are the subject of a new leaflet from Radiovisor Parent Ltd. There are a number of illustrations of recent multiple control installations to show the number of possible applications.

Circle **83** *for further details.*

General Purpose Relay

Pamphlet P.6002/2, Issue 2, gives full details of the miniature general purpose relay G.P.S.T., manufactured by Ericsson Telephones Ltd. This has been introduced to satisfy the demand for a miniature relay having more contact springs than before and is particularly suitable for computer applications.

Circle **84** *for further details.*

Photoelectronics in Industry

In a recent publication from Photoelectronics (M.O.M.) Ltd., brief details are given of some of the standard photoelectronic controls now available.

Circle **85** *for further details.*

Multifix

Loughborough Glass Co. Ltd. have produced a brochure dealing with Multifix multipurpose apparatus for the laboratory and workshop. Illustrations of the equipment described in the text are included and there is a list of complete assemblies.

Circle **86** *for further details.*

Application Design Manual

C. A. Norgren Ltd. has recently produced a publication concerned with their Micro-Fog bearing lubrication system. The design manual ENT-1 explains this system for the benefit of design and plant engineers, for the correct installation of the Norgren system, either from the drawing board or as a conversion of existing systems in machines requiring improved lubrication.

Circle **87** *for further details.*

Miniature Switches

The wide range of precision miniature switches, manufactured by Castelco (Great Britain) Ltd., are the subject of a new catalogue. This range includes door, pendant, torpedo, miniature cord pull, and toggle switches. There is a retail price list at the back of the catalogue.

Circle **88** *for further details.*

Mullard Technical Communications

The August, 1961, issue of Mullard Technical Communications contains, among others, the following articles: "Infra-red Burglar Alarm using OCP71 Phototransistor", by J. A. Everist, and "Measurement of Semiconductor Diode Transient Characteristics", by D. F. Grollet.

Circle **89** *for further details.*

Parkerizing

Parkerizing is a double stage process which consists of firstly converting the ferrous metal surface into a non-metallic crystalline phosphate coating which is integral with the base metal. This highly-absorbent film is then impregnated with a suitable organic finishing medium, thus providing a good corrosion-resistant surface.

The advantages, scope, range of processes and sequence of operations are described in a leaflet available from the Metal Finishing Division of The Pyrene Co. Ltd.

Circle **90** *for further details.*

INSTRUMENT APPLICATIONS

Furnace Behaviour Survey Completed at Corby

A SURVEY of temperature distribution on a blast furnace stove has been completed at Stewarts and Lloyds Ltd. using a Honeywell 40 point data handling unit. By means of a pinboard-programming system the unit processed temperature information on to punched tape, for subsequent computer analysis.

The investigations were carried out by Stewarts and Lloyds in collaboration with the British Iron and Steel Research Association, and this is the first stove in the United Kingdom to be so studied.

The data handling unit worked over a period of ten days under dusty conditions, although it was not designed for such use.

Digital Weighing of Refuse

To speed up the Borough's refuse collection, Wandsworth Council have installed a digital weighing information system, designed and manufactured by the Digital Engineering Co. Ltd.

The new installation records and analyses details of vehicles emptying their loads—vehicle identification, weights of refuse carried, times of weighing, etc.—and reduces subsequent clerical work to a minimum.

The data is automatically punched into tape, and fed into a tape-to-card converter. The punched cards are then put through a tabulator to produce a record of each individual weighing. Subsequent analysis enables payment to be made according to the tonnage collected.

When a loaded vehicle is driven on to the weighbridge and stopped, the angular position of the pointer is turned into digital form via a robustly constructed digitising switch.

This switch is operated by the decimal print-out mechanism of the Ashworth Ross weighprinter indicator, which makes contact with the weighing unit only when the pointer has come to rest. The digitised output is fed from the control console in a form suitable to programme a 5-channel tape perforator.

Operation of the printing button records the weight both in decimal form on the Ashworth Ross weighprinter ticket and internal master record, as well as incorporating it in the data being punched into paper tape. The other details being punched into tape are time of weighing, vehicle identification number, and "instructions" to the punched card installation which subsequently analyses the tape record.

At the control console facilities are available for identifying a weight as either gross or tare (debit or credit), and this is automatically recorded on the tape each time the equipment is operated.

A development of the supervisory facilities inherent in the system is now under consideration so that there will always be available an up-to-the-minute picture of vehicles passing the weighing point.

Consequent upon this, there is a proposition whereby the operation of the weighing button would cause electrical impulses to be sent along a rented Post Office line to a central point where they would operate a page printer and associated 5-channel tape perforator.

Thus the system would give an up-to-the-minute picture of weighings carried out, and the punched paper tape would be available for analyses in the normal way.

"Proximitor" Controls Custard Powder Hopper Levels

CONTINUOUS production packaging of custard powder at the Greenwich plant of Glenvilles Ltd. is assisted by an electronic high and low level Proximitor hopper switch.

Custard powder is taken by elevator directly from the mixers and dropped into the feed hoppers which are situated immediately over the filling machines. Fitted to the hoppers are two probes.

Custard powder being fed into the hopper by the elevator, on reaching the top probe, causes a relay to operate, thus automatically shutting off the elevator drive motor.

On the level of the custard reaching the lower probe the relay again automatically starts the motor and the elevator.

This cycle continues during the whole of the production run and of course can be cut off at any time by means of the main switch.

This method of level control is of considerable help since the hopper is high up and overflowing and wastage has been eliminated.

High-temperature Equipment on the Bristol 188

SPECIAL equipment has been developed by the Aircraft Electrical Division of The Plessey Co. Ltd. for the new Bristol 188 research aircraft due to make its first flight later this year.

The Plessey 10 amp and 25 amp "S" type relays have been redesigned to operate at 250°C. In addition two types of single coil latching contactors and a 200 amp changeover relay have been designed to meet special requirements. All these relays are hermetically sealed and will be covered by full type approval.

I.C.T. Private Exhibition in Scotland

INTERNATIONAL COMPUTERS AND TABULATORS LTD. held a private exhibition in the McLellan Galleries, Glasgow, from November 13th to 16th inclusive.

The exhibits included representative machines from I.C.T.'s 21, 40 and 80 column range of conventional punched-card equipment as well as their 555 plugged programme computer and their new Type 558 electronic computer, first shown at the recent Business Efficiency Exhibition in London.

All the machines were demonstrating typical applications. In addition, I.C.T. films on computer applications were shown and there were lectures, specifically intended for student members of Scottish professional bodies.

At the exhibition a contract was placed by Anderson Boyes & Co. Ltd. for an I.C.T. 1202 computer and tabulator and ancillary equipment valued at £55,000.

I.C.T.'s first installation in Scotland dates back fifty years when their punched-card machines were installed in the office of the Registrar-General for the 1911 census. Today over 200 Scottish organisations, large and small, in commerce, industry, national and local government and nationalised enterprises, make use of I.C.T. equipment.

MEETINGS

December—January

British Institution of Radio Engineers

London Meetings

Dec. 6th. Computer and Medical Electronics Group. Discussion on possible uses of computers in medical diagnosis. To be opened by A. D. Booth, D.Sc., *at 6 p.m.*

Jan. 3rd. Symposium on Data Transmission. This is an all day meeting commencing *at 10 a.m.*

Jan. 17th. Computer Group. "VERDAN—a Miniature Computer for Airborne Use". P. B. Rayner, B.A., and S. Morleigh. *At 6 p.m.*

Jan. 17th. Electro-Acoustics Group. Joint meeting with the Acoustics Group of the Institute of Physics and the Physical Society, "The Calibration of Microphones and Hydrophones". *Royal Horticultural Hall, London, S.W.1, at 2 p.m.*

Jan. 24th. Electro-Acoustics Group. "The Development of a Very High Quality Loudspeaker System". D. A. Barlow, M.Sc., and H. J. Leak. *At 6-30 p.m.*, preceded at 5-30 p.m. by a Special General Meeting of Corporate Members of the Institution.

All meetings will be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, unless otherwise stated.

Southern Section

Jan. 10th. "Automatic Assessment of Transistor Life Test Data". K. Walker and M. J. Crouch. *Southampton University, at 7 p.m.*

South Wales Section

Dec. 6th. "Microwave Valves". R. W. White, B.Sc.

Jan. 10th. "Test Equipment for Television Transmission Links". L. A. Tanner, B.Sc.

All meetings will be held at the Welsh College of Advanced Technology, Cardiff, at 6-30 p.m.

South Western Section

Dec. 20th. Annual General Meeting of the Section followed by "V.H.F. Communications Receivers and Transmitters using Transistors". A. J. Rees. *School of Management Studies, Bristol, at 6 p.m.*

West Midlands Section

Dec. 6th. An all day symposium on "New Electronic Techniques in Non-destructive Testing". *Wolverhampton College of Technology, at 7-15 p.m.*

Dec. 21st. "The R.R.E. Radio Telescope Interferometer". H. Gent. *Birmingham University, at 6-15 p.m.*

Scottish Section

Dec. 13th. At Edinburgh and then repeated on Dec. 14th in Glasgow. "Jodrell Bank". J. B. Wilson, M.A., M.Sc.

Jan. 10th. At Edinburgh and then repeated on Jan. 11th in Glasgow. "Nuclear Reactor Safety Circuits". T. M. Dowell, B.Sc., A.R.C.S.I.

Glasgow meetings will be held at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow; Edinburgh meetings will be held at the Department of Natural Philosophy, The University, Drummond Street, Edinburgh, commencing at 7 p.m.

Merseyside Section

Dec. 13th. "Nuclear Power Station Instrumentation". M. W. Jervis, M.Sc.Tech. *The Walker Art Gallery, Liverpool at 7-30 p.m.*

North Eastern Section

Dec. 13th. "Masers and Parametric Amplifiers". T. H. Wilmshurst, Ph.D. *Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle-upon-Tyne, at 6 p.m.*

East Midlands Section

Dec. 6th. "Transistors in Computers and Control Equipment". P. James. *University of Leicester, University Road, at 6-45 p.m.*

The Institution of Electronics

Dec. 8th. A lecture meeting. *Peterborough Technical College, Eastfield Road, Peterborough at 7-15 p.m.*

Dec. 15th. A film show on electronic topics. *The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, at 7 p.m.*

The Institution of Heating and Ventilating Engineers

Dec. 19th. Scottish Branch. Meeting. "Vibration Isolation". E. H. Sims. *Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C.2, at 7 p.m.*

Jan. 2nd. South Western Branch. Meeting. "The Application of Pneumatic Controls to Air Conditioning with special reference to High Velocity Air Conditioning". G. F. Brown, M.I.H.V.E. *R.W.A. School of Architecture, Bristol, at 6-30 p.m.*

Jan. 9th. Birmingham and District Branch. "Design and Application of Packaged Boilers and Automatic Stokers". R. D. Northcote, A.M.I.H.V.E. *Engineering Centre, Stephenson Place, Birmingham, at 6-30 p.m.*

The Institution of Plant Engineers

Dec. 6th. Leicester Branch. "Silicones in Engineering Applications". G. B. Ingram, B.Sc. *Grand Hotel, Leicester, at 7-30 p.m.*

Dec. 7th. Birmingham Branch. "Electronic Control in Industry with Particular Reference to Automation". *Hotel Leofric, Coventry, at 7-30 p.m.*

Dec. 20th. Kent Branch. "Molybdenum Disulphide as a Lubricant". D. E. Burton. *South Eastern Gas Board Lecture Hall, 95 High Street, Rochester, at 7 p.m.*

Dec. 21st. Blackburn Branch. "The Merits of Various Heat Generation and Distribution Systems". R. A. Wiggans, A.M.I.Plant E. *Castle Hotel, Blackburn, at 7-30 p.m.*

The Institution of Production Engineers

Jan. 6th. Midlands Region. "Recent Developments in Automatic and Semi-automatic Welding". L. H. Morgan, M.I.W. *Wolverhampton & Staffs. College of Technology, at 7-15 p.m.*

The Radar & Electronics Association

Jan. 11th. "Digital Telemetering". J. B. Richardson, B.A. *Lecture Hall, Royal Society of Arts, John Adam Street, Adelphi, London, W.1, at 7 p.m.*

Society of Environmental Engineers

Jan. 10th Lecture on the generation and control of humidity. K. Davis. *Imperial College, Mechanical Engineering Department, Exhibition Road, London, S.W.7, at 6 p.m.*

Society of Instrument Technology

London Meetings

Dec. 13th. Control Section. "Application of Complex Plane Methods to Systems Design". P. K. McPherson, M.Sc., A.M.I.Mech.E.

Jan. 10th. Data Processing Section. "A Review of Digital Computer Control Applications". E. M. Grabbe, M.A.P.S., M.I.R.E.

Jan. 22nd. Control Section. Exposition, 5 *p.m.* "Recent Developments in Automatic Boiler Control Practice".

Jan. 30th. "Digital Tachometry, Tachogenerators and their Extension to Instantaneous Tachometry". M. W. Sage, M.A.

All meetings will be held at Manson House, 26 Portland Place, London, W.1, at 6-30 p.m. for 7 p.m. unless otherwise stated.

Bristol Section

Dec. 14th. "The Atomic Clock". Dr. L. Essen, O.B.E., F.R.S., D.Sc., A.M.I.E.E., F.B.H.I.

Jan. 23rd. "Automatic Machine-tool Control". G. H. Stearman, B.Sc.

All meetings will be held at the Department of Physics, University of Bristol, The Royal Fort, Bristol, 8, at 7-30 p.m.

Chester Section

Dec. 12th. "Design, Application and Selection of Automatic Control Valves". P. Stone.

Jan. 25th. "Any Questions?". Panel: J. W. Broadhurst, S. F. Grover and J. Woodley.

All meetings will be held at Stanley Palace, Watergate Street, Chester, at 7 p.m.

East Midland Section

Dec. 14th. Visit to Rolls-Royce Works, Derby. Details to be promulgated locally.

Jan. 18th. "Commissioning and Operation of Steam Turbines". P. F. Carson.

The Nottingham and District Technical College, Burton Street, Nottingham, at 6-45 p.m. for 7-30 p.m.

Fawley Section

Jan. 5th. "Measurement of Flow". J. Singer, A.M.I.Mech.E. *Room 4a, Administration Building, Esso Petroleum Co. Ltd., Fawley, at 5-45 p.m.*

Grangemouth Section

Dec. 21st. "Instrumentation of Space Vehicles". Dr. A. E. Roy, B.Sc., F.R.Ae.S.

Jan. 18th. "Characteristics of Differential Producers for Flow Measurement". H. E. Dall.

All meetings will be held at the Leapark Hotel Bo'ness Road, Grangemouth, at 7 p.m.

Liverpool Section

Dec. 14th. "The Versatility of the Electronic Potentiometer". F. W. J. Howard.

Jan. 11th. "The Versatility of the D.P. Cell". A. H. Issac, B.Sc., A.M.I.Chem.E.

All meetings will be held at the Merseyside and North Wales Electricity Board Industrial Centre, Paradise Street, Liverpool, at 7 p.m.

Manchester Section

Dec. 13th. "Instrumentation for Oil Fired Glass Furnaces". N. I. Walker.

Literary and Philosophical Society, 36 George Street, Manchester, 1, at 6-45 p.m.

Midland Section

Dec. 8th. "Instruments in Clinical Chemistry". N. Crawford. "Electronics in Surgery". R. Lightwood. *Lecture Theatre of the Byng Kendrick Suite of the Gosta Green College of Technology, Aston Street, Birmingham, at 6-30 p.m. for 7 p.m.*

Scottish Section

Jan. 26th. "Flameproofing and Intrinsic Safety in Instrumentation". Dr. G. Morris, B.Sc. *Scottish Building Centre, Sauchiehall Street, Glasgow, at 7-15 p.m.*

South Wales Section

Jan. 31st. "Computers and their Application". E. Stuart, B.Sc., A.R.C.S. *Welsh College of Advanced Technology, Cathays Park, Cardiff, at 6-45 p.m.*

South Yorkshire Section

Jan. 3rd. "Film Night". *Brown-Firth Research Laboratories, Princess Street, Sheffield, 4, at 7 p.m.*

Women's Engineering Society

Jan. 8th. London Branch. Bluebird Project. D. Stevens. *Hope House, 45 Great Peter Street, Westminster, S.W.1, at 7 p.m.*

(*Continued from page* 1589)

Stone-Platt Guide

Stone-Platt Industries Ltd. has recently issued a reference book which is aimed to provide the reader at home and overseas with concise and factual information on the products and services of group companies.

The activities of the companies within the group range from marine and mechanical to electrical and electronic engineering. The most familiar names to our readers among these no doubt being Epsylon Industries Ltd. and Epsylon Research & Development Co. Ltd.

Circle **91** *for further details.*

The "Journal of Applied Pneumatics"

Vol. 4 of the *Journal of Applied Pneumatics*, the house journal of Martonair Ltd., contains various articles of interest. The first article is entitled "Coil Winding for Television Receivers" and mentions the coil winding machines designed and built by the Works Technical Services Department of the Coventry Radio and Television factory of the General Electric Co. Ltd., using Martonair pneumatic equipment. Also of interest is an article on "Correct Lubrication of Pneumatic Equipment".

Circle **92** *for further details.*

Co-ordinate Table

The Dowding-Atlantic co-ordinate table has been developed for rapidly and accurately locating the positions of hole centres automatically, and enabling any drilling layout to be repeated at any future time with equal precision. The system, which incorporates Ferranti electronic control, is the subject of a brochure available from Dowding & Doll Ltd.

Circle **93** *for further details.*

Meters

The Cambridge magnetic oxygen meters, described in List 281/2, have been developed for the determination of oxygen concentrations using methods based on the high paramagnetic susceptibility of the gas.

Two types are available, the filament type and the annulus type. The instruments are similar in external appearance but incorporate different interchangeable analyser units. They are largely complementary and have a wide range of industrial applications, especially in the measurement of oxygen in boiler and cement flue gases.

Circle **94** *for further details.*

Cables

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Circle **95** *for further details.*

(*Continued on page* 1595)

Circle 352 for further information

$$H_o = \left[H_t + \frac{S(t-t_s) - m(t-t_o)}{1 + m(t-t_o)} \right] \frac{g_L}{g_s} \text{ ins Hg.}$$

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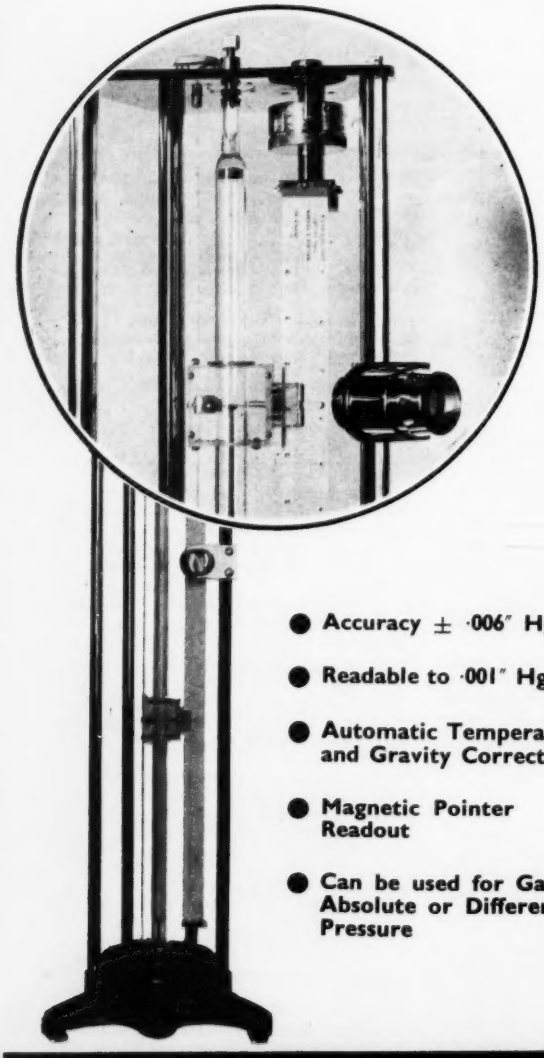

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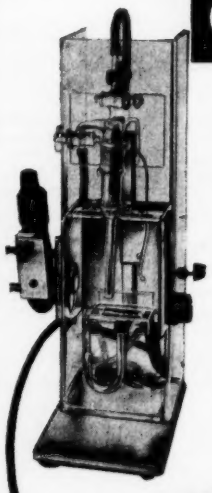

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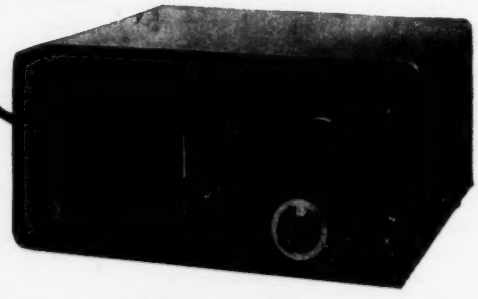

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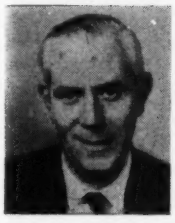
Mr. J. L. Lunn

Mr. E. G. Barber



Mr. J. A. Enwright

PERSONALITIES

Mr. R. Chaffey

The English Electric Co. Ltd. have made three new senior appointments to their Control Gear Division at Kidsgrove.

Mr. F. E. Waspe, A.M.I.E.E. (chief development engineer), is responsible, with his design staff of engineers and draughtsmen, for the company's range of multi-motor control centres, and his team is actively engaged in the application of the most modern techniques to the development of motor control gear.

Mr. G. N. Gunnell, A.M.I.E.E. (chief control engineer), is responsible for all the control engineering for the company's multi-motor centres and also for the application of all forms of variable speed drives, static switching and control gear for machine tool drives and for the iron and steel industry.

Mr. E. J. Pepper, A.M.I.E.E. (chief design engineer), is responsible for the component circuitry for industrial drives and control equipment where static equipment such as magnetic amplifiers and semiconductors are employed.

These appointments are intended to streamline the Division's research and development programme.

Mr. R. Foxwell, the chairman of The Wayne Kerr Engineering Co. Ltd., has appointed **Mr. G. L. Ball, B.Eng., A.M.I.E.E.,** as sales director and **Mr. J. A. Enwright** a director.

Mr. Enwright joined the company as sales and contracts manager in 1953 and progressed to general manager in 1955.

Mr. Ball joined Wayne Kerr as general sales manager in 1958.

Mr. D. J. Venning has been made sales director of New Electronic Products Ltd. He will be responsible for the sales of the company's medical, industrial and scientific equipment in the United Kingdom and abroad. Mr. Venning was previously microswitch sales manager at Honeywell. He has been succeeded by **Mr. J. L. Lunn** who has specialised in microswitch sales with the company for a number of years.

Mr. F. Jasper is to be the sales director of the new Shipton Group amalgamation, Shipton Automation (Sales) Ltd. He has been general sales manager of Modern Telephones Ltd., and marketing manager of Telephone Rentals Ltd.

Shipton Automation (Sales) Ltd. have the sole selling agencies in Britain for Siemens & Halske communications equipment and Stenocord dictating systems.

Dr. D. A. Bell has been appointed director of the new AMF Ltd. Research Laboratory at Peppard, near Henley-on-Thames. Dr. Bell was previously on the staff of the Electrical Engineering Department at the University of Birmingham.

A Fellow of the Physical Society, Dr. Bell is also vice-president of the Association of University Teachers (1960-61 session), and chairman of the Birmingham branch of the British Computer Society.

W. T. Marchment, who for 15 years has been divisional manager of the Instrumentation & Controls Division of Evershed and Vignoles Ltd., has now been elected to the board of directors. Mr. Marchment, who is a past chairman of B.I.M.C.A.M., was one of the first industrial executives to realise the potentialities of electronics in the process control industries, and was particularly active in the field of petroleum refinery controls. He was the author of an important paper on electronic control in oil refineries which was presented a decade ago before the Instrument Society of America and laid the foundations for a great deal of the work which has been done in this field.

The British Aircraft Corporation Ltd. have appointed **Mr. E. G. Barber, B.Sc., A.F.R.Ae.S.,** as group education officer. Mr. Barber will be responsible for the supervision and co-ordination of education and training facilities of the member companies within the British Aircraft Corporation.

Dr. Keith B. Harvey has joined the staff of the National Bureau of Standards, U.S. Department of Commerce, as a visiting scientist. As a member of the Physical Properties Section of the Mineral Products Division during this year at NBS, Dr. Harvey will study methods of visualising dislocations, causes of dislocation, and the interaction of dislocations with other defects in sodium chloride and aluminium oxide single crystals.

Dr. Harvey, a native of England, studied for a B.Sc. degree in physics and mathematics from London University (external) from 1951 to 1956. He was also a technical assistant with the Imperial Chemical Industries during that time. After receiving a Ph.D. in physics from the University of Bristol in 1959, Dr. Harvey returned to I.C.I. as a technical officer. He is currently on leave of absence from I.C.I.

Mr. D. H. Maxwell, sales manager of the Transmission Division of Telephone Manufacturing Co. Ltd., is at present on a tour of the Middle and Far East, including such places as Turkey, Iraq, Pakistan, Singapore, Malaya, British North Borneo, Brunei, Sarawak and Egypt.

This tour is part of the company's project of establishing an overseas direct selling organisation now that they have terminated the transmission sales arrangement with A.T. & E.

Apart from visiting newly appointed agents and Pye's overseas offices and telecommunication representatives, Mr. Maxwell will be conducting an on the spot market survey with existing and potential customers for the company's range of transmission equipment.

Because of greatly increased managerial responsibilities within the Elliott-Automation Group as a whole, the chairman of the Rheostatic Co. Ltd., Mr. M. J. Gartside, is relinquishing his appointment as managing director, but remaining as chairman. He is succeeded by **Mr. J. H. Stevens,** who is a director and the general manager of the company.

Mr. Hemsley C. F. Miller, who has been associated with the company since its foundation, has retired for health reasons, and **Mr. E. O. Herzfeld,** director of Elliott-Automation, and **Mr. G. C. Fairbanks,** director of Elliott Brothers (London) Ltd., have joined the board.

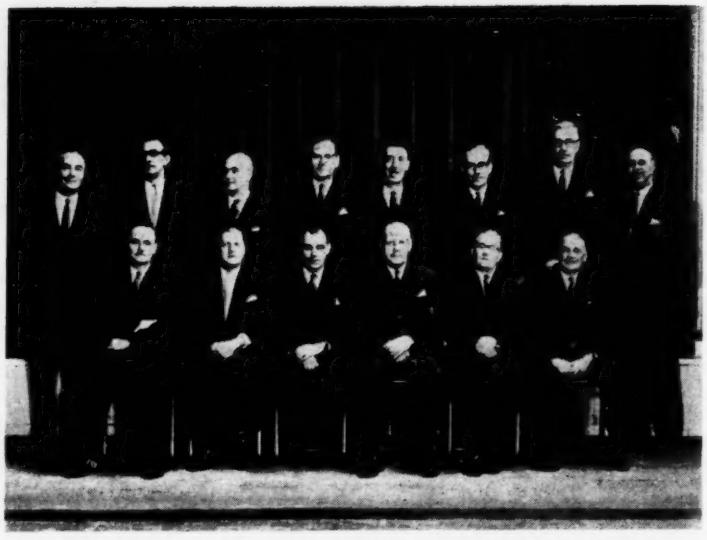
Mr. R. Chaffey is to be the new deputy commercial manager of Marconi Instruments Ltd. He joined the company in 1940 and carried out his preliminary training in the production department, being particularly concerned with calibration and basic standards. He has also spent part of his time as head of the company's instrumentation sales department of the Canadian Marconi Co.

Mr. R. V. Whelpton has been appointed director of the Signals Research and Development Establishment at Christchurch, Hants. Mr. Whelpton took up his new appointment at the beginning of November.

Ultra Electronics Ltd. have made several new appointments to their projects office staff. **Mr. G. B. Wood, B.Sc.,** has joined the company as a projects officer; **Mr. J. E. Hills** is to be sales engineer (Telecommunications); **Mr. I. D. Condon** is now marketing consultant to the Ultra Electronics Automatic Business Equipment Group; and **Mr. J. B. Gillespie** is to control home sales.

To clarify the positions of the various members of the projects team the titles of certain personnel have been changed.

The following are now sales manager in their respective groups: **Mr. A. E. Outten** (Telecommunications); **Mr. R. J. Russell-Bates** (Control & Instrumentation); **Mr. V. G. Sampson** (Special Products); and **Mr. R. A. Seal** (Automatic Business Equipment). The present projects officers in these groups will now be known as sales engineers and the title projects officer will apply only to two senior executives, Mr. G. B. Wood and one other yet to be appointed. **Mr. R. J. Williams** is now projects manager and **Mr. D. S. MacIntyre** is now general sales manager.



The 14 new M.I. Group regional managers (back row, left to right)—H. R. Renfree (N.E. Yorkshire), A. S. Brain (North-western and North Wales), W. J. Weston (South-western), F. D. Gough (Northern), B. G. Scott (N.W. London), W. H. Soper (Midlands), B. L. Perkins (Eastern), F. W. Whiting (N.E. Midlands); (front row)—F. R. Williams (South Wales), W. Jones (Mid-Southern), R. W. Puttock (S.E. London), W. J. A. Gemmell (Scotland), S. T. Wood (S.W. Yorkshire) and E. G. Harrison (Central London).

Sir Eric Jones, K.C.M.G., C.B., C.B.E., who from 1952 until last year was director of Government Communications Headquarters at the Foreign Office, has joined Associated Electrical Industries Ltd. as a consultant.

A.E.I. have made two new appointments in their Heavy Plant Division: **Mr. J. A. Garrod, M.Eng., A.M.I.E.E.,** becomes engineer-in-charge, Control Equipments, Plant Applications Engineering Department; **Mr. G. H. Sutton, Assoc.I.E.E.,** becomes commercial engineer-in-charge, Rolling Mills, Large Electrical Machine Sales.

The new manager of the Computer Engineering Department of A.E.I. Electronic Apparatus Division, Trafford Park, is **Mr. J. C. Gladman, B.Sc.** He joined Metropolitan-Vickers Electrical Co. Ltd. as an engineer in the radio department and worked on, among other things, airborne radar, telemetering equipment for guided weapons and the design and application of digital computers. Mr. Gladman was transferred to the Computer Department as assistant chief engineer and as a result of the formation of the A.E.I. Electronic Apparatus Division was appointed assistant manager of the Computer Engineering Department.

Mr. D. G. Booth, M.I.Mech.E., is the new divisional general manager of the Industrial Hydraulic Division, at Cheney Manor, of The Plessey Co. Ltd.

Included in this division is a new production unit which will be manufacturing the Hydro-Stabil range of equipment following the licence agreement concluded by Plessey with Guldner-Motoren-Werke last April. Mr. Booth was associated with this division at its inception and he now returns to it after spending the past two years as engineering executive of The Plessey Swindon Region.

Mr. E. E. Webster has been appointed general manager of the Swindon Region of The Plessey Co. Ltd. He joined Plessey in 1950 as chief inspector and subsequently became divisional manager of the Capacitors and Resistors Division. In 1959 Mr. Webster was appointed management executive responsible to Mr. A. E. Underwood for production operations of the company and its subsidiaries in the Swindon region.

Following the completion of the merger between The Plessey Co. Ltd., Automatic Telephone and Electric Co. Ltd., and Ericsson Telephones Ltd., **Mr. A. F. Roger,** chairman of Automatic Telephone and Electric Co. Ltd., and **Sir Harold A. Wernher, Bt., G.C.V.O., T.D.,** chairman of Ericsson Telephones Ltd., have been appointed to the board of directors of The Plessey Co. Ltd.

The British Scientific Instrument Research Association has appointed **Mr. R. E. Fischbacher, B.Sc., A.R.C.S.T., A.M.I.E.E.,** as assistant director. Mr. Fischbacher served for 12 years in the Admiralty Signal and Radar Establishment as a member of the R.N.S.S. before joining B.S.I.R.A. in 1957 to become head of the electronics department.

Rear Admiral J. Y. Thompson, C.B., has joined Elliott Brothers (London) Ltd., to assume special responsibilities in connection with the company's work for the Royal Navy. After commanding an aircraft carrier in the Korean war, Rear Admiral Thompson was subsequently appointed director of the Gunnery Division of the Naval Staff and latterly Admiral Superintendent of the Chatham dockyard.

Mr. W. G. Bond has been appointed a joint general manager of Elliott Brothers (London) Ltd. Mr. Bond has been responsible for the mechanical handling, conveying and industrial weighing activities of the company for a number of years and has played a part in expanding this side of the company's business to its present size.

Mr. G. B. R. Feilden, F.R.S., has resigned his present directorships in order to join the board of Davy-Ashmore Ltd. as technical director. Mr. Feilden will be based at the Group's London headquarters at 15 Portland Place, W.1, and will also be joining the boards of the principal operating companies of the Davy-Ashmore Group.

Mr. N. R. D. Gurney, A.C.G.I., M.I.E.E., has recently been appointed general manager of Davy-A.E.I. Automation Ltd. He is also a director of the company.

Mr. Gurney was previously Manchester executive to the Heavy Plant Division of A.E.I.

The Council for Scientific and Industrial Research has appointed **Dr. John Vernon Dunworth, C.B.E.,** as deputy director, National Physical Laboratory, D.S.I.R., in succession to Dr. G. Macfarlane, who is shortly to take up the appointment of director of the Royal Radar Establishment, Malvern. Dr. Dunworth is at present deputy director of the Atomic Energy Establishment, Winfrith.

To co-ordinate the marketing arrangements of a number of companies within the group, **Metal Industries Ltd.** have established 14 regional offices in the United Kingdom and appointed new regional managers. (See photograph above.)

Mr. Gordon Wansbrough-White, assistant to the Group organisation and methods officer, Metal Industries Ltd., has been appointed organisation and methods officer of the M.I. Group's biggest subsidiary, Brookhirst Igranic Ltd.

Another Brookhirst Igranic appointment announced is that of **Mr. J. H. Comley** as production controller at the Bedford works. Mr. Comley was previously with a sister company, Foster Transformers.

Mr. L. F. E. Coombs has joined the technical sales department of Smiths Aviation Division. He will be concerned with the marketing of the company's extensive range of engine instruments and equipment from the Division's headquarters. Mr. Coombs was for several years engaged on design and development work with Handley Page and Delaney Gallay.

Mr. K. Brockhouse Hogg has been appointed general works manager of Electronic Instruments Ltd. He was educated in both England and Scotland as well as obtaining a post-graduate diploma in business administration at Syracuse University, New York State.

Mr. F. Seely has joined the Semiconductor Division of Mullard Ltd. as sales manager and will immediately become responsible to the Division's commercial manager.

Brigadier John Clemow, formerly chief engineer, Weapons, and a special director of Vickers Armstrongs (Aircraft) Ltd., has been appointed engineering director of G.E.C. (Electronics) Ltd.

The following appointments have also been noted:

Advance Components Ltd., senior technical representative (southern area), W. F. Martin.

Castrol Industrial Ltd. (Industrial Division), sales manager, C. W. Page.

Dewhurst & Partner Ltd., sales manager (western area) E. Trattles.

Electro-Mechanisms Ltd., technical sales manager, F. A. Ramage, A.M.Brit.I.R.E.

Stanhope-Seta Ltd., technical and development manager, R. Oakman.

Quickfit & Quartz Ltd., overseas representative, R. Mackenzie.

OBITUARIES

Brush Electrical Engineering Co. announce with deep regret the death, on 27th October, of their vice-chairman, **Dr. Brian Laidlaw Goodlet, O.B.E., M.A., Sc.D., M.I.Mech.E., M.I.E.E.** Dr. Goodlet was born in Russia in 1903 and came to this country when he was 16. From 1923 to 1930 he was with the Metropolitan-Vickers Electrical Co. Ltd. and from there he went to Cambridge to study, and then back to Metropolitan-Vickers. In 1936 he obtained the Chair of Electrical Engineering at the University of Cape Town, South Africa. During the war he was in the South African navy and in 1943 the Admiralty asked that he be seconded to them as Chief Scientist, Admiralty Underwater Explosion Research Station at Rosyth, where he started work on underwater weapons and counter-measures. At the end of the war Dr. Goodlet returned to Cape Town as Dean of the Faculty of Engineering and in 1950 he came to England as deputy chief engineer of A.E.R.E. at Harwell. In 1956 Dr. Goodlet left Harwell to join Brush Electrical Engineering Co. as chief engineer and director. Among his many distinctions Dr. Goodlet was a member of the Governing Body of the Loughborough College of Technology and previously a member of the Nuclear Energy Panel and chairman of the Naval Education Advisory Committee.

One of the last remaining links with Lord Kelvin has been broken by the death of **Mr. F. A. King,** former director of Kelvin & Hughes. Mr. King was awarded the C.B.E. for his part in the supply of instruments and equipment to all three services in the Second World War. With the amalgamation of Kelvin, Bottomley and Baird in 1935, of which he was managing director, and Henry Hughes Ltd., Mr. King became joint managing director, with Mr. G. B. G. Potter, of the new company Kelvin & Hughes Ltd., a position he held until he became consultant director to the company. Mr. King retired from Kelvin & Hughes Ltd. in 1955 after completing fifty five years' service.

It is announced with regret that **Mr. A. G. Lang,** of the Electrical Measurement Division of Elliott Brothers (London) Ltd., who recently completed 50 years' service with the company, died as a result of serious injuries incurred in a road accident.

He joined Siemens Brothers in 1912, becoming manager of the Measuring Instrument Department and was transferred to Elliott Brothers as sales manager of the Electrical Measurement Division in 1941.

Mr. Lang's many activities included service on several technical committees in connection with B.E.A.M.A. and he was chairman of the Instrument Transformer Committee.

It is announced with regret that **Mr. J. P. Gregory, B.Sc.(Eng.), A.M.I.E.E.,** assistant manager at Rugby of the Control Gear Engineering Department, A.E.I. Motor & Control Gear Division, passed away on 31st October at the age of forty-seven.

After completing a student apprenticeship with the British Thomson-Houston Co., Mr. Gregory joined the Control Gear Engineering Department where he specialised on industrial contactor control. In 1959 he was appointed assistant manager of the Control Gear Engineering Department. For a number of years Mr. Gregory had been a British Electrical and Allied Manufacturers' Association representative on several of the B.S.I. Crane Committees.

(*Continued from page* 1591)

Clear Fronted Instruments

Sangamo Weston Ltd. has recently issued a brochure describing their newly-introduced range of clear fronted instruments together with a photograph of a typical example. Included in this new range are d.c. moving coil, a.c. rectifier and h.f. thermocouple types. The various ranges available and dimensions are also given.

Circle **96** *for further details.*

Seals

A leaflet describing hermetic metal/ceramic brazed seals has just been published by Lodge Plugs Ltd. These are high-temperature, high-strength hermetic assemblies incorporating high-conductivity copper, matched metals and 95% alumina from the SINTOX range of ceramics.

Circle **97** *for further details.*

Magnadur Permanent Magnets

The latest publication from the Component Division of Mullard Ltd. is entitled "Mullard Magnadur Permanent Magnets". The booklet contains information about the various types of Magnadur magnets and their particular applications. Factors governing the length and cross-sectional area of any permanent magnet are discussed and some general rules are given for the guidance of designers using Magnadur.

Circle **98** *for further details.*

Bellofram

George Angus & Co. Ltd. have produced a 16-page design manual describing the Bellofram rolling diaphragm, which is the most recent development in the general field of diaphragms.

Among the typical applications given are those classified under instruments, which can convert pressure into corresponding force or displacement with extreme accuracy and repeatability. Design, dimensional and technical data are also given.

Circle **99** *for further details.*

Industrial Molyslip

"Keeping Things Moving in Industry" is the title of a 10-page illustrated booklet dealing with the industrial Molyslip range of molybdenum disulphide products manufactured by the Slip Group of Companies.

The booklet is being issued to industry through Monks & Crane, the sole industrial distributors of all Molyslip products, and contains, in addition to details of the distribution service and prices, descriptions of the various lubrication processes.

Circle **100** *for further details.*

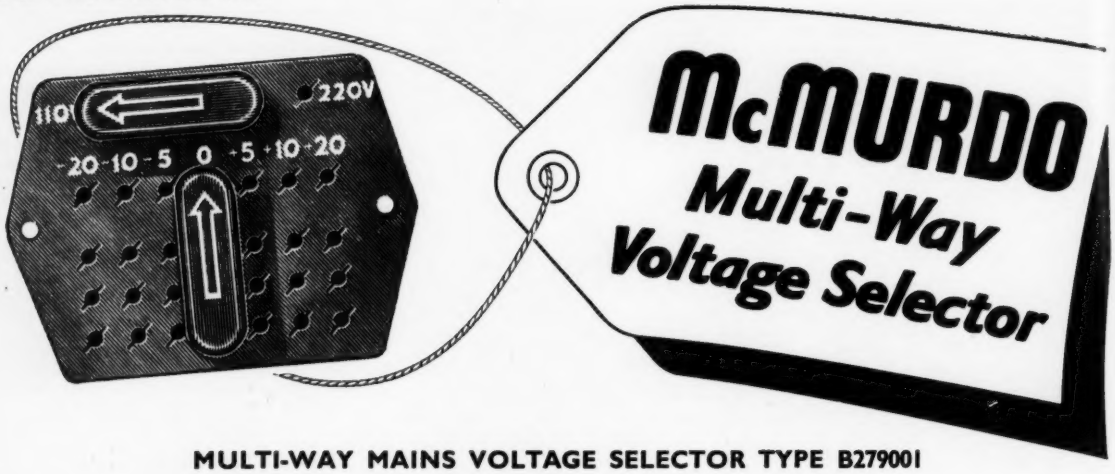
Spectrum Analyser Techniques

Polarad Electronics Corporation of New York has recently produced the third edition of a booklet on spectrum analyser techniques. This booklet contains details of the general theory of operation, together with a number of illustrations. Part of the handbook is devoted to a list of specifications and applications.

Circle **101** *for further details.*

(*Continued on page* 1598)

Circle 354 for further information



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Yes, you can—and you certainly can't afford expensive guesswork. Brodie-Kent meters give you precise running records, exact control, and accurate mixes.

'Mmm. Perhaps we should try one.'
Yes. Get in touch with Gilbarco's Technical Advisory Service first—they know all about Brodie-Kent.

'Yes, good idea.'
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'You're right, of course. (Are they all like this at Brodie-Kent?)'

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SOCIETY OF INSTRUMENT TECHNOLOGY

Manchester Section

At the Committee Meeting held on the 25th September, 1961, Dr. Stainthorpe stated that he had now been able to agree a date for the symposium on distillation columns to be held jointly with the Institute of Chemical Engineers and the Institute of Petroleum. This symposium will be held on the 20th March, 1962. It was also agreed in committee that we should publish a foolscap size poster announcing the Manchester Section Meetings until the end of 1961, and to publish a further poster which would be distributed during January, 1962, which will announce meetings up to and including the A.G.M. on the 14th May, 1962. These posters have now been printed and circulated with a covering letter to over 200 educational institutions and industrial concerns within the Manchester area. Some of these posters sent out may have tended to overlap with the sections adjacent to Manchester, but this has been done as some company employees may in actual fact live nearer to Manchester than the relative adjacent section's meeting place. The chairman, Mr. G. D. Coombes, reported on a North Western Regional Committee Meeting which he attended, and amongst the items which were discussed was the suggestion of the formation of a further section in the North West at Warrington. Opposing views were considered, and it has been tentatively decided to hold a joint meeting at Warrington where a suitable lecture will be given, and from this meeting it is hoped to be able to judge whether the response warrants a section being formed in Warrington. The next Committee Meeting would be held on Monday, the 4th December, 1961, in the Common Room of the Chemical Engineering Department, Manchester College of Science & Technology at Jackson Street, Manchester. We wish to thank the Governors, and Dr. Stainthorpe in particular, for the use of this room.

We have now had our first meeting on Monday, the 9th October, in the small Lecture Hall at the Literary & Philosophical Society, 36 George Street, Manchester, 1. This is an extremely pleasant room, and we have to thank the caretakers, Mr. and Mrs. Bocock, for their hospitality and wonderful catering. If this catering is representative of what we will receive in the future, there is no doubt when word gets around amongst our members that we will have many more attending our meetings. The secretary read out a very impressive list of new members admitted to the Manchester Section, and despite our recent loss of members who were transferred to the newly formed section called Lancaster & Lakeland Section, our membership still increases and now stands between 180/200 members. The new poster announcing our programme to the end of the year was shown to the members, and it was requested that anybody in the Manchester area who has not one of these posters, either in their office or works, should contact H. E. Manicom, 32 Deansgate, Manchester, 3. It was also announced that a dinner-dance has been arranged at the Café Royal, Manchester, for Friday, the 30th March, 1962, and the committee of Messrs. Maley, Manicom and Westbrook, has been formed to look after this and other social functions.

Mr. R. Clare, B.Sc., Member of the Institute of Fuel, then addressed the meeting on "Instruments as an aid to Fuel Efficiency". Mr. Clare started by saying that he wanted to talk about his organisation, which is the National Industrial Fuel Efficiency Service, and the way that they use instruments. In the Manchester Branch they have over 600 instruments of many different types, and a selection of these was exhibited at the meeting. Amongst these were two types of recording flow meters, a CO_2 outfit, two German portable indicators, one for wet and dry bulb measurement and the other for surface temperature measurement, an induction coil for measuring electrical loads, a heat prover and other items including two museum pieces in the form of what orifice plates should not be like. Mr. Clare said that one of their greatest problems is getting manufacturers to make truly portable equipment, and quite a lot of their time is spent in building up standard racks and stands to take equipment to make is portable. Before a set of instruments it sent out from the branch on a survey, calibrations in all cases are rigorously checked. After transportation to site a further calibration check is carried out, and when the equipment is returned to the branch it is once again checked over. They have found from experience that less damage is caused by transporting mercury flow meters filled with mercury and water with the valves closed, and also less mercury tended to be lost. Generally speaking they find very little damage to the instruments due to transportation. On most plants visited it is surprising to note that very few instruments are installed to check on fuel efficiency of the plant with the exception of boiler plants. It seldom occurs to users to hold spare instruments which they can use for investigation purposes. On very many plants instruments have been fitted, but due to lack of interest thay have fallen out of use. Their work is primarily to carry out heat and power surveys, and of course a lot of this is concentrated on boiler plants, with a high percentage of these plants with too few instruments installed. Many engineers prefer to fit a feed meter rather than a steam meter on a boiler plant, but Mr. Clare gave the reasons why he recommends the use of a steam flow meter, and these are as follows:

1. It measures boiler load
2. One does not have to allow for blow down
3. It is not affected by reciprocating feed pumps
4. It has quick response to load changes, quicker than pressure gauge
5. Recording and integrating meter can be used on steam, whereas an integrating meter can only be used on feed where reciprocating feed pumps are used.

Mr. Clare stated that one drawback of the steam flow meter was that a pressure change of 100/75 lb/in^2 would mean a change of 12% in the reading. However, some companies provide pressure compensation on their steam flow meters, and others a recording pen on the same chart as the steam flow pen, and in the latter case allowances can be made for the varying steam pressure. They have to carry out coal sampling tests, and this is usually done back in the Branch Laboratory, but one of their greatest difficulties is to get an accurate idea of the amount of fuel burnt over a given period. So many users are trying to make an intelligent guess at their fuel stocks which can be so far out as to make nonsense of their efficiency figures.

Temperature measurement, particularly in side flues of Lancashire boilers, can be very useful in determining the economics of flue cleaning. A fair amount of use is made of suction pyrometers which can show up to 100°F higher temperature than thermocouples in conventional pockets. It is found that this type of measurement is of extreme use in kiln and furnace temperatures, and although the suction pyrometer takes rather longer to set up for reliable measurement, the results are worth while. Their organisation finds that generally speaking larger savings can be made on process plant by their investigations than on boiler plant. As Mr. Clare said, most industrial driers have an efficiency of less than 50%, and quite a high percentage of down to 25%. All these investigations have to be done by measurement before any recommendation can be made to their customer, and usually one of their suggestions to the customers is that they recommend that portable instruments should be held so that occasional checks can be made to determine the efficiency of various pieces of plant. During the questions Mr. Clare was asked to explain some of their methods of calibration, and he said that,

as far as thermocouples are concerned, in all cases they tend to use Chromel/Alumel type of thermocouples in preference to resistance bulbs, and they would expect to discard a thermocouple long before any kind of contamination was apparent. The batch characteristics of the thermocouple wires were known, and also checked, and any corrections needed were applied to their reading instruments. Flow meters were given head checks, and also mercury levels, etc., were checked. Galvanometer and potentiometric instruments were checked against workshop potentiometers, pressure gauges by a dead weight tester, and a filled thermal system by substandard thermometers. On site pressure gauges will be checked with a substandard pressure gauge. Oxygen meters are not used with the exception of the heat prover, due to the difficulty in making the equipment portable, and also setting it up on site. Inferential methods are used for determining efficiencies on low pressure hot water systems. They do very little work on water analysis as the water filtration companies are very well set up to do this type of work.

Mr. Clare wound up by saying that N.I.F.E.S. is a non-profit making organisation still receiving subsidies mainly from the N.C.B. and other nationalised undertakings. However, it is hoped within the organisation that one of these days they will be entirely self-supporting.

The talk was very well received, and appreciation was shown by the applause after a vote of thanks given by Mr. Coombes.

Mr. Maley then announced the arrangements made for the visits to the Daily Express Building in Manchester on Monday, the 23rd October, and Monday, the 30th October, and the meeting closed. The next meeting was on Monday, the 13th November, when a joint meeting with the Institute of Physics and the Physical Society of Manchester heard a paper given by Dr. L. J. R. Postle, Ph.D., Associate of the Institute of Physics, and his subject was "The Role of the Physicist in Plant Instrumentation ".

South Wales Section

THE opening meeting of the 1961/62 Session was held in the Physics Lecture Theatre of the Welsh College of Advanced Technology, Cardiff, on 27th September, 1961, the section chairman, Mr. A. D. Thomas, in the chair.

After welcoming members and friends the chairman said that the lecturer, Mr. H. Burns, of the Distillers Co. Ltd., had agreed at very short notice to read a paper to the Section. The committee were indebted to Mr. Burns who would speak on " Instrumentation in the Physical Testing of Plastics ".

In his opening remarks the lecturer explained, with numerous examples, how widely the physical properties of modern plastic materials can vary over a range of materials from the polystyrenes, polyethylenes, to the synthetic rubbers and expanded foams, including a whole family of resin bonded laminates and products. For this reason specialised equipment was generally designed to test one single material or to cover a narrow range of physical properties.

The difficulties in obtaining reliable performance information on complicated finished products from the data derived from the physical testing of small test specimens was emphasised. As a result, from time to time special tests must be devised for evaluating the more complex stresses that prevailed in finished articles.

On mechanical testing, descriptions were given of the Instrom testing machine, Hounsfield tensometer, Cross breaking tester, and three impact testers (falling weight, Charpy and Izod).

Mr. Burns described a fatigue testing machine employing a photoelectric device designed and constructed by his company. The breaking of the specimen breaks allowed light to fall on an OCP71 photo transistor, which caused the machine and a clock or counter to stop. This enabled long term fatigue tests to be performed without supervision.

Amongst the newer applications of plastics was the use of polythene or p.v.c. as pipe material for the conveyance of fluids and, for the testing of these pipes, a pipe bursting equipment was described. This consisted of several temperature controlled water baths with pressurised pipe specimens immersed in them. The time to burst was a criterion of performance.

Dealing with electrical testing, Mr. Burns described several tests including the Hartshorn and Ward dielectric test set. Resistivity measurement, breakdown voltage equipment and a recent E.R.A. tracking tester, in which an electrolytic solution was pumped between two high voltage electrodes resting on the sample.

On rheological testing, instrumentation on a Research Extruder was described, including accurate temperature control and polymer pressure measurement.

The problem of ageing—the degradation caused by exposure to wide or narrow band spectral radiation—and methods of measuring its effects by natural and accelerated exposure were described.

The lecture concluded with a showing of the film " Plastics-Today and Tomorrow ", featuring the production, research and technical service facilities of the Plastics Group of the Distillers Co. Ltd., at Barry, Glamorgan.

A short discussion period followed the lecture and the meeting closed with a vote of thanks proposed by Mr. W. Somerville Vernon.

Tees-side Section

IN the presence of nineteen members and nine visitors, Mr. B. W. Ramsay, section chairman, opened the 101st Ordinary Meeting and introduced the speaker for the evening, Mr. N. Burley, of the General Post Office.

Mr. Burley opened his lecture, entitled " Automation in the Post Office ", by defining his subject to include subscriber trunk dialling, the automatic Telex system and postal mechanisation.

The speaker first described the basic system of dialling and then went on to discuss the equipment necessary for trunk dialling. Before the war, both local and distant subscribers' trunk exchanges were manually operated but by 1945 this system was improved to the extent that only one manual trunk exchange was required. Recently a completely automatic subscriber trunk dialling system was introduced and at present there are 100 exchanges in operation.

The automatic Telex system was introduced in 1945 and this enables a teleprinter operator to enjoy a method of operation similar to that of trunk dialling and eliminating the intermediate manual operators. The Telex system now links Great Britain with most of the Western European cities and provides a rapid and efficient means of communication.

Mr. Burley then demonstrated the Telex and the subscriber trunk dialling systems with equipment which was connected to the Middlesbrough and Leeds main telephone exchanges. This was followed by a most interesting film entitled " Postal Mechanisation ".

A lively discussion was opened by Mr. G. Randle and a warmly supported vote of thanks was proposed by Mr. L. Ludbrook.

(*Continued from page* 1595)

Relays and Switches

The latest literature from Ericsson Telephones Ltd. gives tentative data on multiple miniature relay units, microsecond pulse triggered relays, a.c. relay Type 53 and solar switches.

Circle **102** *for further details.*

Machine Lubrication Catalogue

The Micro-Fog lubrication equipment catalogue published by C. A. Norgren Ltd. illustrates and describes the required components recommended for use in machine lubrication from among the company's range of compressed air lubricators, filters and regulators and other accessories.

Circle **103** *for further details.*

Merchen Pneumatic Scale Feeder

Publication No. S/269 from Wallace & Tiernan Ltd. describes a pneumatic weigh-feeding device, recently introduced by the company, which can be used both for the blending of several dry chemicals or for the addition of one or more dry chemicals to a liquid.

Circle **104** *for further details.*

Cobalt-Platinum Permanent Magnet Alloy

Johnson Matthey has issued a new data sheet describing their cobalt-platinum permanent magnet alloy Platinax II. This publication gives information on the heat treatment process, on reversible permeability, and on behaviour at elevated temperatures.

Circle **105** *for further details.*

Clean Air

Photoelectronics (M.O.M.) Ltd. have produced a leaflet in connection with the Clean Air Act of 1957 and three of its products, namely the smoke alarm, Type CCSA, the smoke density indicator, Type CCSI, and recorders.

Circle **106** *for further details.*

Position Control

The latest addition to the series of E.M.I. machine tool position control systems is the EMICON B100, capable of controlling machine movements driven by electric or hydraulic servo systems, Ward Leonard controls, or a.c. motors with clutches.

Complete technical specification details of this control system are given in a new leaflet published by E.M.I. Electronics Ltd., which also gives details of the types of tapes and teleprinters used with the B100 and outlines programming facilities.

Circle **107** *for further details.*

Oscilloscope

A wide band oscilloscope, the E.M.I. Type WM16, with a range of plug-in preamplifiers providing differential, high gain and dual trace input facilities, as well as the normal 40 Mc/s wide band input, is described in a new leaflet published by E.M.I. Electronics Ltd.

The leaflet contains a number of illustrations together with a comprehensive list of technical specifications.

Circle **108** *for further details.*

Computer Leaflet

The EMIAC II analogue computer is the subject of a booklet published by E.M.I. Electronics Ltd.

This illustrated leaflet contains several examples of typical problems dealt with by EMIAC II in the fields of automobile, chemical, structural and aeronautical engineering.

The EMIAC II makes use of interchangeable "C" boxes which allow a tailor-made system to be supplied to solve a specific type of problem at the price of a mass produced instrument. The implications of the "C" box are dealt with in great detail in the leaflet.

The computer has been designed so that every individual component will perform its computing function with an accuracy of better than 0·1%.

Circle **109** *for further details.*

Workshop Projector

Publication 141/61 from Optical Measuring Tools Ltd. gives details of the latest addition to the company's range of high precision optical inspection equipment. The 15 in. universal projector has been developed for the basic purpose of determining the accuracy of contours such as templates, gears, cam forms, screw threads, etc.

Specification details are included together with an illustration of the universal projector.

Circle **110** *for further details.*

Synthetic Crystals

Section P of the Hilger & Watts Ltd. loose-leaf catalogue is now available. It gives details of the different types, sizes, mountings and resolutions of the complete range of Hilger crystal phosphors and crystal photomultiplier assemblies.

The section on optical crystals lists the complete range of types and sizes, together with information on refractive indices, approximate transmission limits and physical properties.

Circle **111** *for further details.*

Precision Control in Chemical Feeding

Technical publication No. S/109 from Wallace & Tiernan Ltd. gives brief details of the development and production of chlorinators, chemical feeders and control apparatus for use in the treatment of water sewage and industrial wastes. Recent additions to the range of equipment include proportioning pumps, precision instruments and aids to navigation.

Circle **112** *for further details.*

Cambridge Instruments

Cambridge Instrument Co. have recently published a series of leaflets detailing ranges of instruments manufactured at their Mechanical Thermometer Division which are now available from stock.

These include dial type thermometers with vapour pressure and mercury in steel systems, temperature regulators, draught and pressure indicators and recorders and humidity instruments.

Circle **113** *for further details.*

Duraglas

Turner Brothers Asbestos Co. Ltd. have recently issued a compact sample card illustrating the comprehensive range of Duraglas tapes for electrical insulation.

All tapes comply with the specification for glass fibre woven tapes reference A/S 79 laid down by the British Electrical and Allied Industries Research Association and are fully described in a booklet issued in conjunction with the sample card.

Circle **114** *for further details.*

High Purity Metals

The latest series of data sheets to be issued by Johnson, Matthey & Co. Ltd. covers their range of high purity metals.

Information is given on 38 metals including noble, rare earth and certain base and rarer metals. The general properties of each element are tabulated and details are given of the forms of current production. In most cases the metals are available in more than one grade, the metallic impurity contents being expressed in parts per million.

Circle **115** *for further details.*

Automat

A 36-page illustrated booklet describing the Automat engineering sets developed by Automat Precision Engineering A.G. of Switzerland has been issued by their agents in this country, International Engineering Concessionaires Ltd.

The Automat engineering sets are made up of precision engineered elements for assembling any desired combination of motions and mechanisms. All sets are accompanied by Automat teaching manuals which demonstrate the theoretical cause and practical effect of each step in three dimensions.

Circle **116** *for further details.*

Solid State Circuit Elements

A six-page leaflet describing their complete range of solid state circuit elements is now available from Telephone Manufacturing Co. Ltd.

The leaflet contains a general introduction to solid state elements as well as comprehensive technical specifications and dimension diagrams of the modulator SM10, amplifier SA10, oscillator SO11 and demodulator SD11. A typical schematic of these elements combined to form a d.c. amplifier is also featured.

Circle **117** *for further details.*

Semiconductor Device Guide

A new and revised edition of the General Electric Co. Ltd. Semiconductor Division's Device Guide is now available.

This new edition contains information on many newly introduced devices including the new subminiature high speed switching diode GEX71, the widened range of medium power Zener diodes SZA/C series and new high power silicon controlled rectifiers. In addition to concise electrical and mechanical specifications of the wide range of G.E.C. semiconductor devices, the new publication includes a list of CV types supplied by the Division with their nearest commercial equivalents and a commercial comparison table.

Circle **118** *for further details.*

"Racal Review"

The October issue of *Racal Review* from Racal Electronics Ltd. deals with, among other subjects, the Racal engine tachometer. This has been developed in consultation with Rolls-Royce and Trans-Canada Airlines to provide a constant means of checking the efficiency of jet engines, in company with other data logged during the engine's life. This instrument meets the requirements of simplicity, economy and does not hamper the aircraft's flying time.

Circle **119** *for further details.*

Motors

A four-page leaflet from Comtex Ltd. describes their Series 8 range of fractional horse power motors.

Specification details together with diagrams are included.

Circle **120** *for further details.*

Mullard "Technical Communications"

The September issue of *Technical Communications* available from Mullard Ltd. contains various articles of interest to readers of this journal. Portable Mains Overvoltage Detector by G. O. Crowther, *et al.*, is concerned with the Mullard Z803U cold trigger tubes; Transistor Backlash Circuits by A. F. Newell and Miss P. A. Tourtel deals with Schmitt and Eccles-Jordan bistable circuits; and an article by P. James, W. A. Hunter and H. A. Bell is concerned with the design of computing circuits for use at frequencies up to 10 Mc/s.

Circle **121** *for further details.*

Deionisers

Deionisers ranging from portable laboratory units to large plants are listed and described in English, French and German in a new 25-page catalogue from Elga Products Ltd.

Circle **122** *for further details.*

"I.C.T. Data Processing Journal"

Among the articles contained in No. 9 of the *I.C.T. Data Processing Journal* are Weighed and Paid, Document Processing with Character Reading, Dinner is Served (from the 1959 annual report of Batchelors Ltd.) and I.C.T. 1301 Data Processing System at Putney Bridge House.

Circle **123** *for further details.*

"De Havilland Gazette"

The August, No. 124, issue of the *De Havilland Gazette* deals with electrical equipment used to expand de Havilland activities for aviation and industry; de Havilland thermo-electric coolers; and flow control with de Havilland Pottermeters used in India's longest pipeline.

Circle **124** *for further details.*

"Platinum Metals Review"

An article on the contamination of platinum metal thermocouples—its causes of failure in hydrogen atmospheres, by H. E. Bennett is to be found in the October issue of the *Platinum Metals Review*, published by Johnson, Matthey & Co. Ltd.

Circle **125** *for further details.*

International Imraks

Leaflet Nos. R/104 and R/105 from Alfred Imhof Ltd. introduce some additions to the Imrak range. An open version of the Imrak has been developed to provide an economical panel framework when it is not necessary for the equipment to be enclosed. Imrak extension plinths may be fitted to an open Imrak to provide greater stability when it is desired to withdraw a heavily loaded chassis or if the equipment tends to make the rack top-heavy. Mobile bases have also been designed so that an Imrak may be transported with safety.

Circle **126** *for further details.*

Metamic

A data sheet No. MRD1/61 dealing with Metamic pyrometer sheaths details the three grades available to meet a wide range of conditions. These are the Metamic 519 for use up to 1,900°C, Metamic 528 for use up to 1,650°C and Metamic 612 for use up to 1,450°C.

The data sheet is available from Morganite Research & Development Ltd.

Circle **127** *for further details.*

George Kent Ltd.

George Kent Ltd. have, during the past few months, issued a number of data sheets.

Specification sheet SS 011 for September deals with the Commander KH series of bell operated low head instruments for the measurement of flow and differential pressure.

Specification sheet SS 012 for August is concerned with the Commander KB series bellows-operated level and pressure instruments. Publication 158 for September gives details of universal miniature primary elements for pH and Redox measurement. Publication 323 for August lists the standard ranges of Multelec Mark 2 temperature instruments, and Publication 2530 for August is devoted to the ST/L manometer spare-parts list.

Circle **128** *for further details.*

B.C.U.R.A. Gazette

The forty-third quarterly gazette of the British Coal Utilisation Research Association is devoted mainly to the Annual General Meeting and Informal Open Day held earlier in the year.

The Gazette also contains an account of the Fourth International Conference on Coal Science, together with an historical background of the conference.

Circle **129** *for further details.*

"Dawe Digest"

The September issue of *Dawe Digest* obtainable from Dawe Instruments Ltd. features a new method of measuring torque; ultrasonic cleaning with trichloroethylene; the new Type 1408D sound level indicator; and flaw detection by Sonoray.

There is also a section referring to the company's recent change of premises.

Circle **130** *for further details.*

Negretti & Zambra

Negretti & Zambra Ltd. have released the following new publications: No. E/16 gives details of a vibration damping bracket for use with Aetec Instruments; E/19/1 provides information on Aetec recording pyrometers, resistance thermometer recorders for the electrical measurement and recording of temperatures over a variety of ranges between −80 and +2,500°F. APP/26 is concerned with centralised temperature indication for hotels, offices, schools, etc.

All three leaflets are illustrated.

Circle **131** *for further details.*

"General Radio Experimenter"

The September issue of *General Radio Experimenter* contains articles on remote control for Variac autotransformers, impact noise analyser, Type 1263B amplitude regulating power supply and six dial decade resistor.

Circle **132** *for further details.*

Oil Burner Control

The latest literature from Radiovisor Parent Ltd. describes their Flamestat automatic oil burner control Type FF 100, which provides photo-electric flame failure protection with automatic control of the lighting cycle.

Circle **133** *for further details.*

Terminal Blocks

High temperature terminal blocks are the subject of a leaflet available from Austin Taylor Electrical Ltd. This range of terminals is designed for use at high temperatures, 250°C continuous, 300°C intermittent. The assembly consists of porcelain blocks with silicon glass fabric separators, mounted on steel channels and can be assembled in any number of ways.

Dimension details are included.

Circle **134** *for further details.*

Humidity Instruments

A 16-page leaflet, List 70/1, issued by the Cambridge Instrument Co. describes their range of hygroscopic and wet and dry bulb humidity indicators, recorders, and controllers. The leaflet begins with an introduction to the measurement of relative humidity and its importance in industry, and describes and illustrates the two common methods of measurement.

The instruments described include a hygroscopic indicator for measuring the moisture content of paper and similar materials, mechanical and electrical wet and dry bulb recorders, combined temperature and humidity recorders and various types of controllers, including a multi-point electronic recorder/controller.

The publication also provides general information on several humidity control systems and contains a short bibliography relating to other sources of information on the measurement and control of humidity.

Circle **135** *for further details.*

Molybdenum Disulphide

The second edition of a booklet entitled Molybdenum Disulphide in Action is now available from K. S. Paul (Molybdenum Disulphide) Ltd.

This new edition contains a number of new reports on applications of molybdenum disulphide, but also retains many of those published in the first edition.

Circle **136** *for further details.*

"Technique"

The October issue of *Technique*, published by Muirhead and Co. Ltd., contains two articles of interest to readers of this journal. These are: "The Importance of Phase Angle in Vibration Work", by L. Yeh, Ph.D., D.I.C., A.M.I.Mech.E., A.M.I.Mar.E., and "The Development of Magslips and Synchros for Nuclear Reactor Control Rod Position Indication", by P. D. Leach.

Circle **137** *for further details.*

Plannair Assembly Cabinet Leaflet

A four-page illustrated leaflet is now available from Plannair Ltd., describing the company's pressurised filtered air assembly cabinet.

The leaflet examines in detail the various features of this cabinet, which provides a dust-free working area for precision made components requiring clean air conditions during assembly. Also included are drawings of the cabinet, together with technical data.

Circle **138** *for further details.*

Transportable Tape Recorder

The RE301 transportable magnetic tape recorder is the latest addition to the well-known range of EMI instruments for the professional user in recording and broadcasting work. A new leaflet describes how, from the earliest stages of development, the aim of EMI has been to produce a flexible two-channel recorder in a transportable form.

Apart from formal studio, theatre and concert hall recordings, the RE301 is being used increasingly for recording phenomena of a transient nature.

Fitted with in-line heads, two separate record and two replay amplifiers, the RE301 can record on either track or both tracks simultaneously. Incoming signals can be checked visually on the level meter and aurally by means of the independent monitor loudspeaker amplifier. Comparison between two signals on either track can be obtained as required.

Circle **139** *for further details.*

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★ *Some articles that have appeared in recent issues*

The Stability of Permanent Magnets
A. G. Clegg, M.Sc., Ph.D.

Components for High-Fidelity Equipment
John Borwick, B.Sc.

Transistors or Valves?
G. F. Penver

Maintaining Specified Standards for Components
S. F. Snowden

Transistors in Experimental Works
F. M. Russell, Ph.D.

Some Aspects of Resistor Life Testing
S. Osborne, B.Sc., A.M.I.E.E., A.M.I.Mech.E.

The Component Comparator: The Key to High-speed Component Testing
K. O. Francis, Grad.I.E.E., Grad. Brit. I.R.E.

Cold-cathode Tubes for Industrial Electronic Controls
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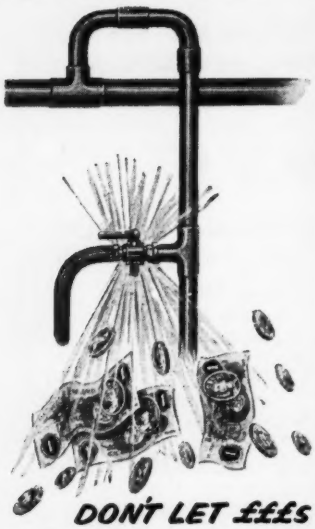
Circle **357** for further information

Circle 358 for further information



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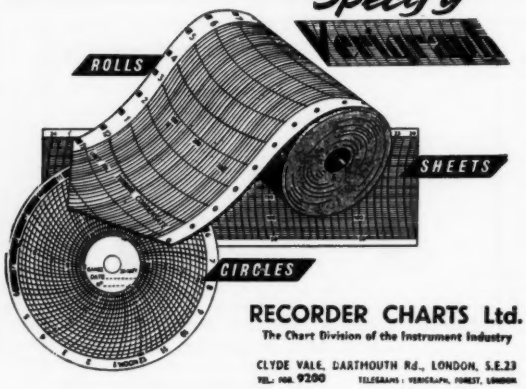

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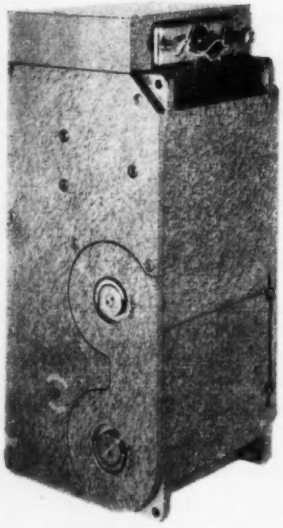

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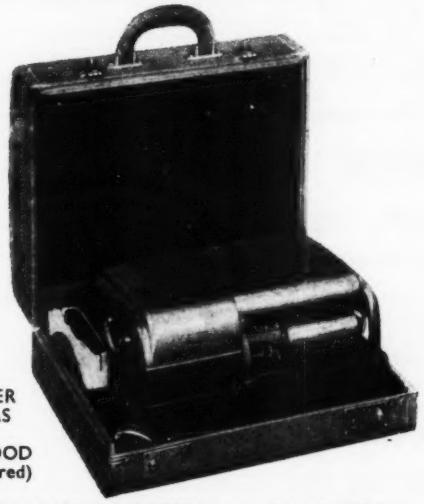

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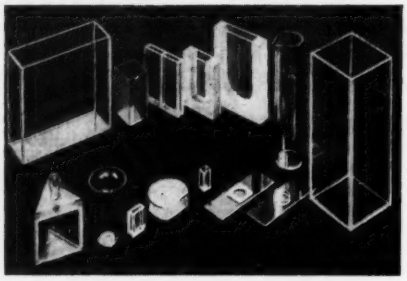

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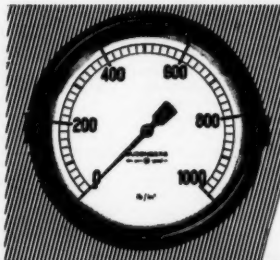

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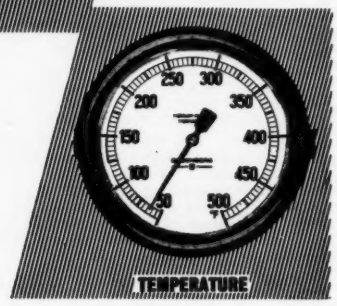

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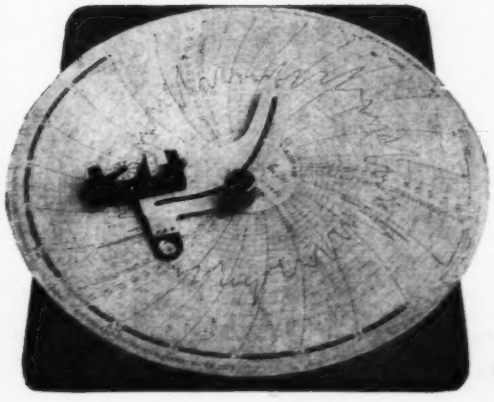

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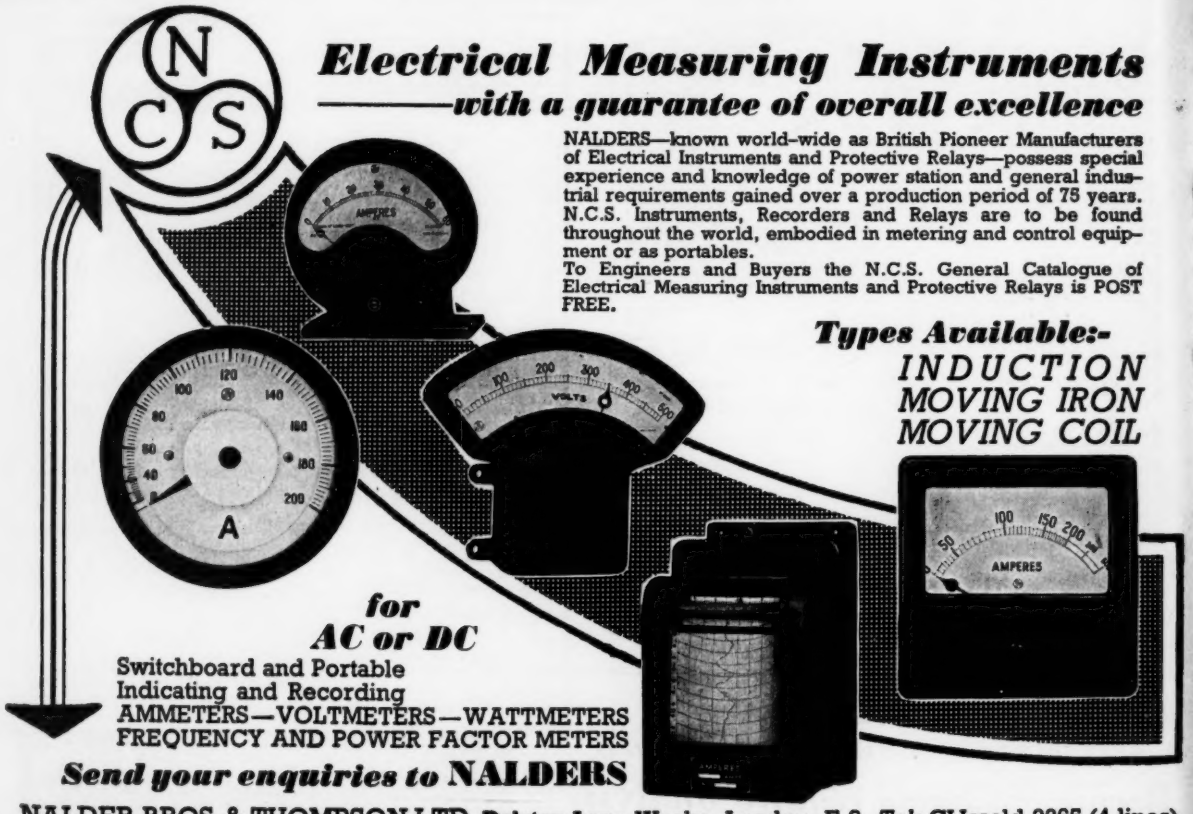

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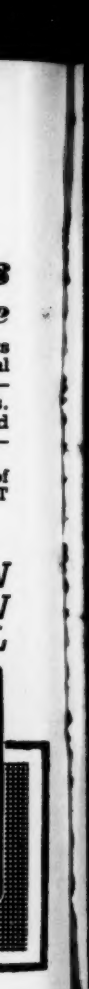

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A.G.A. - A.S.M.E. and I.S.O. Coefficients

In Figs. 9 to 12 The symbols △,○,□ and ▲,●,■ refer to points on the α versus R characteristic with meanings as follows:

△△, referring to a 10-in diameter main, determines the extent of the strictly experimental characteristic

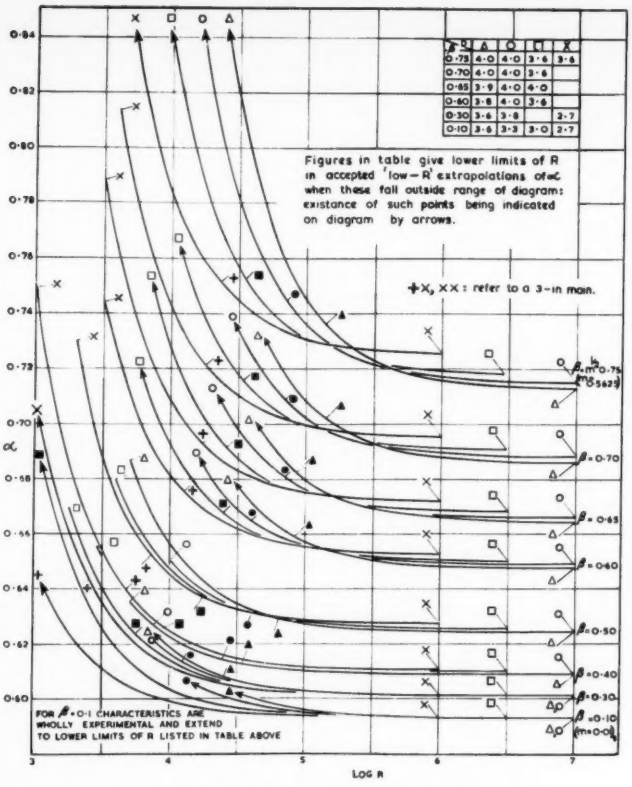
△△, referring to a 10-in diameter main, determines the extent of the characteristic when extended to include the maximum accepted extrapolation into low Reynolds numbers

●○ refer to a 6-in diameter main and indicate, in similar fashion, the extent of the ○○ extrapolated and "experimental + extrapolated" characteristic

■□ refer to a 3-in diameter main and indicate the extent of the experimental and □□ "experimental + extrapolated" range of the characteristic

With similar meaning the pairs of terms ⊕⊘, ⊘⊘ and + X, X X are used with reference to other pipe diameters as indicated on the diagrams on which the symbols occur.

In Figs. 13 to 17 in which the characteristics are entirely experimental, the symbols △,○,□ refer to characteristics of 10-in, 6-in, and 3-in diameter mains respectively whilst ⊘ and X refer to mains of diameter 12-in and 2-in respectively


Figures in table give lower limits of R in accepted 'low – R' extrapolations of α when these fall outside range of diagram: existance of such points being indicated on diagram by arrows.
+X, XX : refer to a 3-in main.
FOR β = 0·1 CHARACTERISTICS ARE WHOLLY EXPERIMENTAL AND EXTEND TO LOWER LIMITS OF R LISTED IN TABLE ABOVE
LOG R

▲ *Fig. 9. A.G.A.-A.S.M.E. orifice with corner taps: α as a function of R and m (after National Bureau of Standards analysis of Beitler's results, see refs. 8 and 4)*

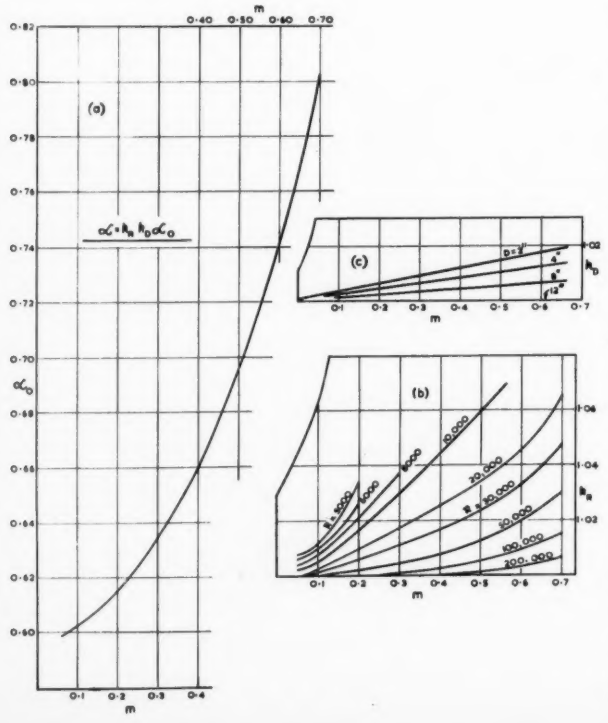
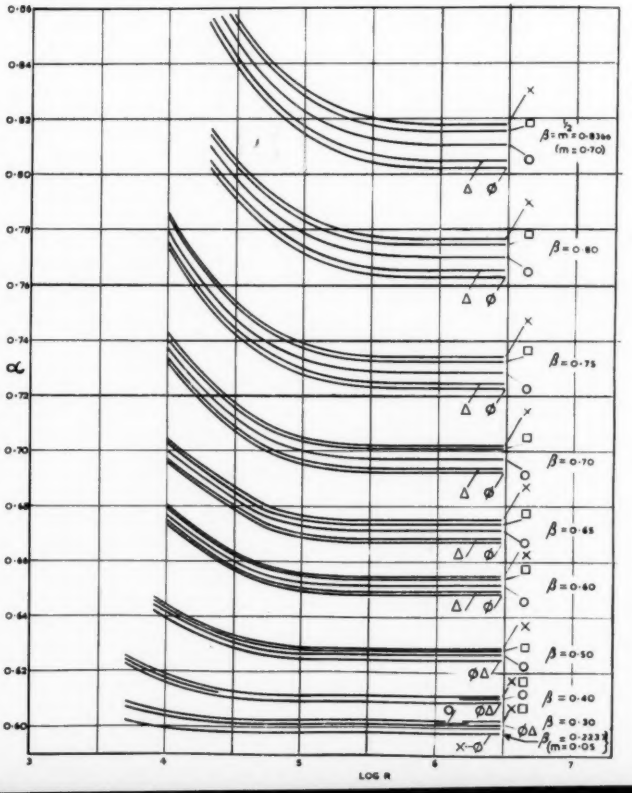


Fig. 13. I.S.O. orifice with corner taps: values of α_0, k_R and k_D (after V.D.I., see ref. 20)

▼ *Fig. 14. I.S.O. orifice with corner taps: α as a function of R and m (after V.D.I., see ref. 20)*



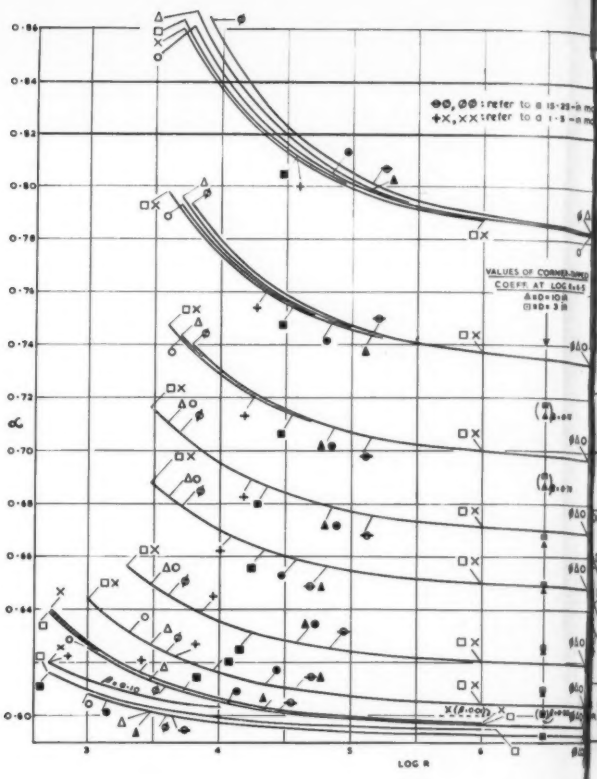


Fig. 10. *A.G.A.-A.S.M.E. orifice with vena-contracta taps:* α *as a function of R and m (after A.G.A.-A.S.M.E., see refs.* 2 *and* 3)

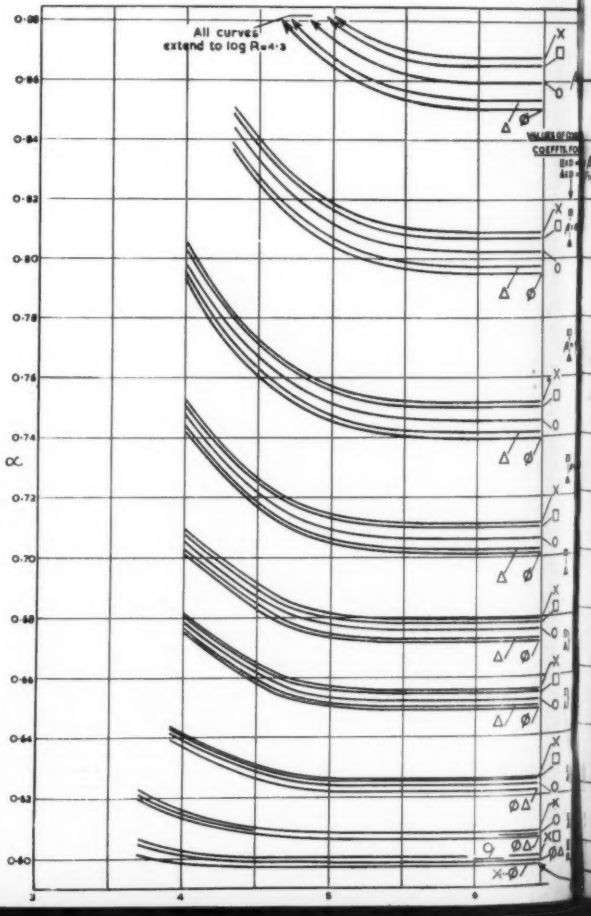
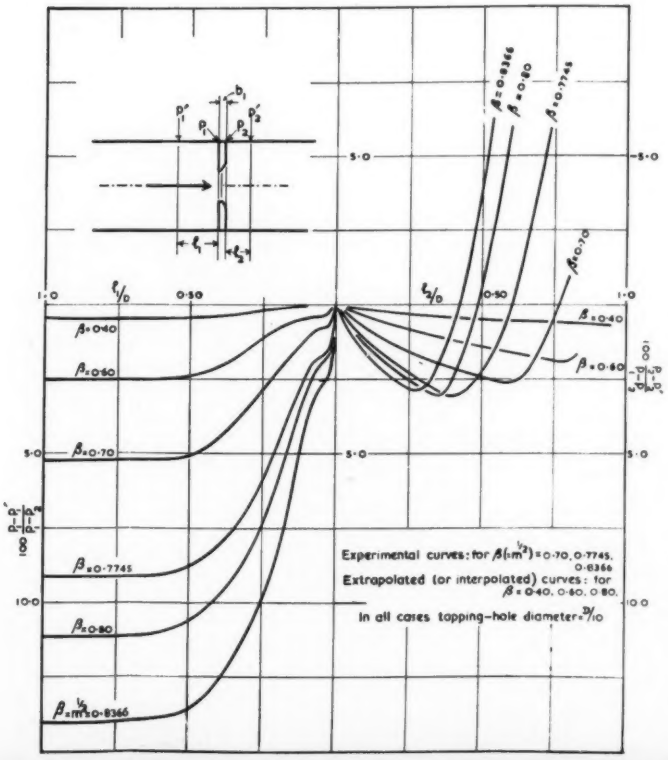


Fig. 16. *I.S.O. orifice with vena-contracta taps:* α *as a function of R and m (after V.D.I. and Witte, see refs.* 20 *and* 15)

▼ *Fig.* 15. *I.S.O. orifice: pressure gradient data (after Witte, see ref.* 15)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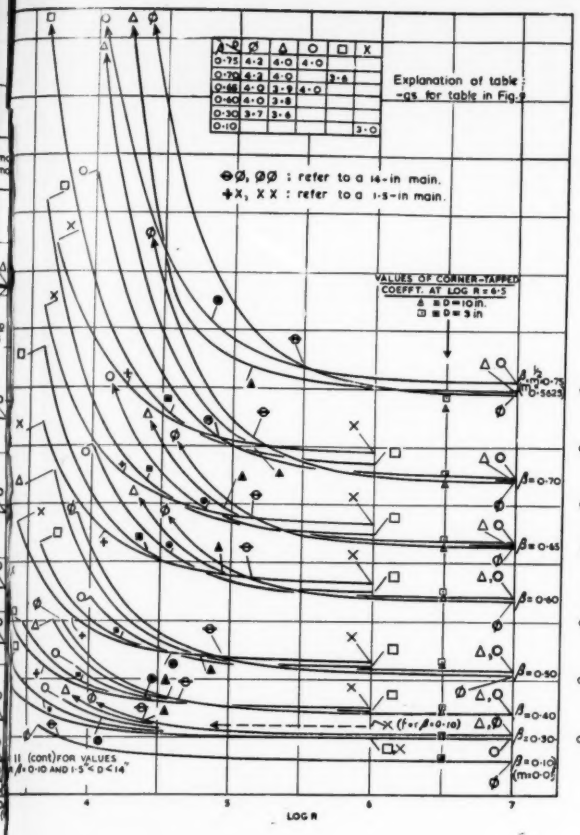
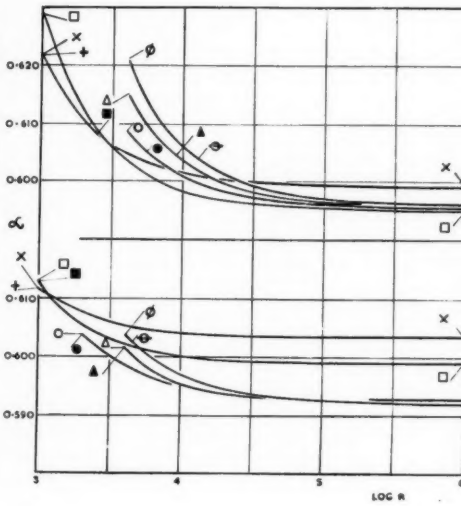
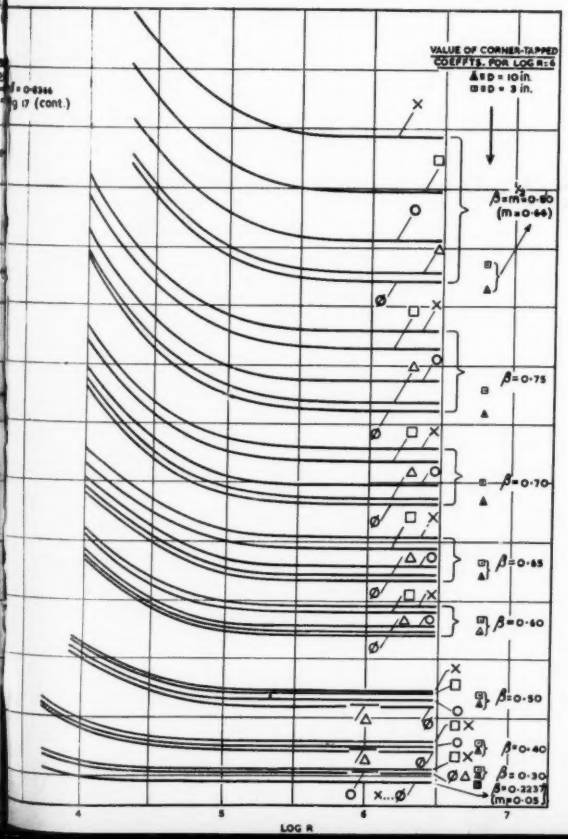

Explanation of table
-as for table in Fig.9
⊖Ø, ØØ : refer to a 14-in main.
+X, XX : refer to a 1-5-in main.
VALUES OF CORNER-TAPPED COEFFT. AT LOG R = 6·5
LOG R

◀ *Fig.* 11. *A.G.A.-A.S.M.E. orifice with f*
α as a function of R and m (after A.G.A.
see refs. 2 *and* 3)

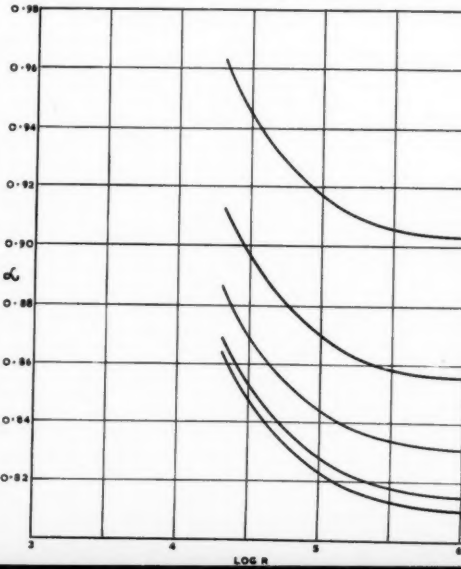
▼ *Fig.* 11 (*continued*)



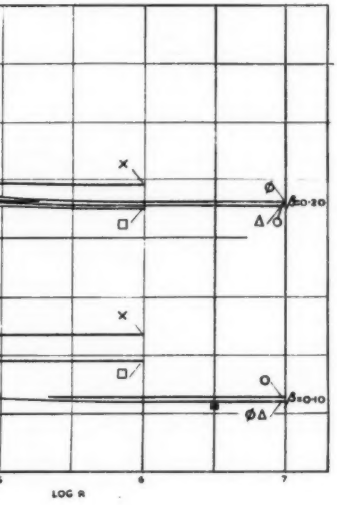


◀ *Fig.* 17. *I.S.O. orifice with flange taps: α*
tion of R and m (after I.S.O. and Witte, s
and 15)

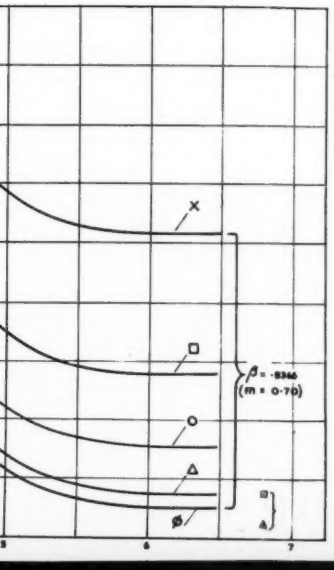
▼ *Fig.* 17 (*continued*)



E. orifice with flange taps:
(after A.G.A.-A.S.M.E.,



h flange taps: α as a func-
O. and Witte, see refs. 20



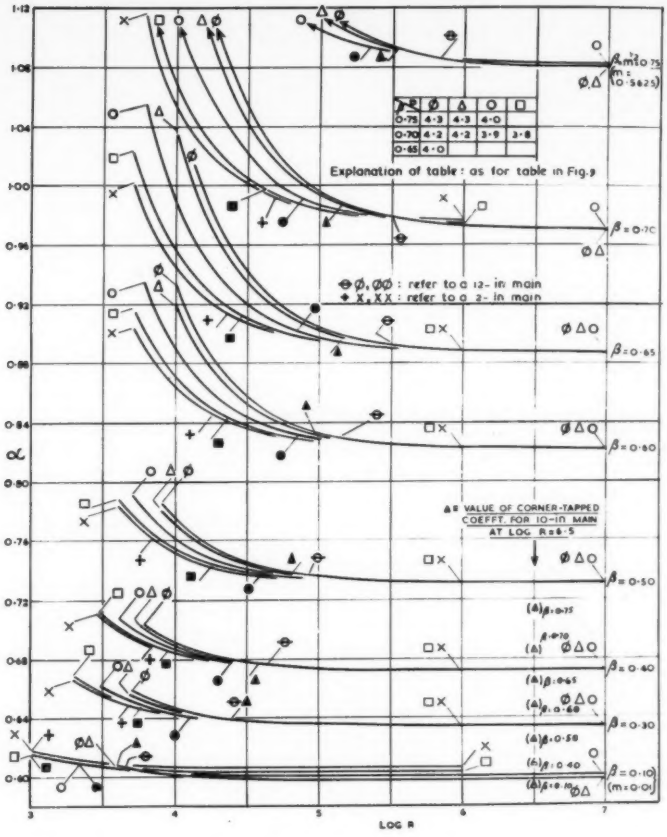

Explanation of table : as for table in Fig.9
⊖Ø, ØØ : refer to a 12- in main
✦ X, XX : refer to a 2- in main
β = 0·70
β = 0·65
β = 0·60
β = 0·50
β = 0·40
β = 0·30
β = 0·10
α
LOG R

Fig. 12. *A.G.A.-A.S.M.E. orifice with pipe taps: α as a function of R and m (after A.G.A.-A.S.M.E., see refs.* 2 *and* 3)

A.G.A. - A.S.M.E. Coefficients

I.S.O. Coefficients